NOVEMBER • 1956

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

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- *Special Report...* Reciprocating Compressors Page 120
- Your Column in Balance? Page 151
- Models Pay Out Page 161

The 72-ton top section of a reactor-regenerator, fabricated at CB&I's Birmingham plant, swings through the air during erection.

Such structures are the result of Chicago Bridge & Iron Company's vast experience and complete facilities *so necessary* to engineer, fabricate and erect refinery structures to exacting specifications. Write our nearest office for further information.

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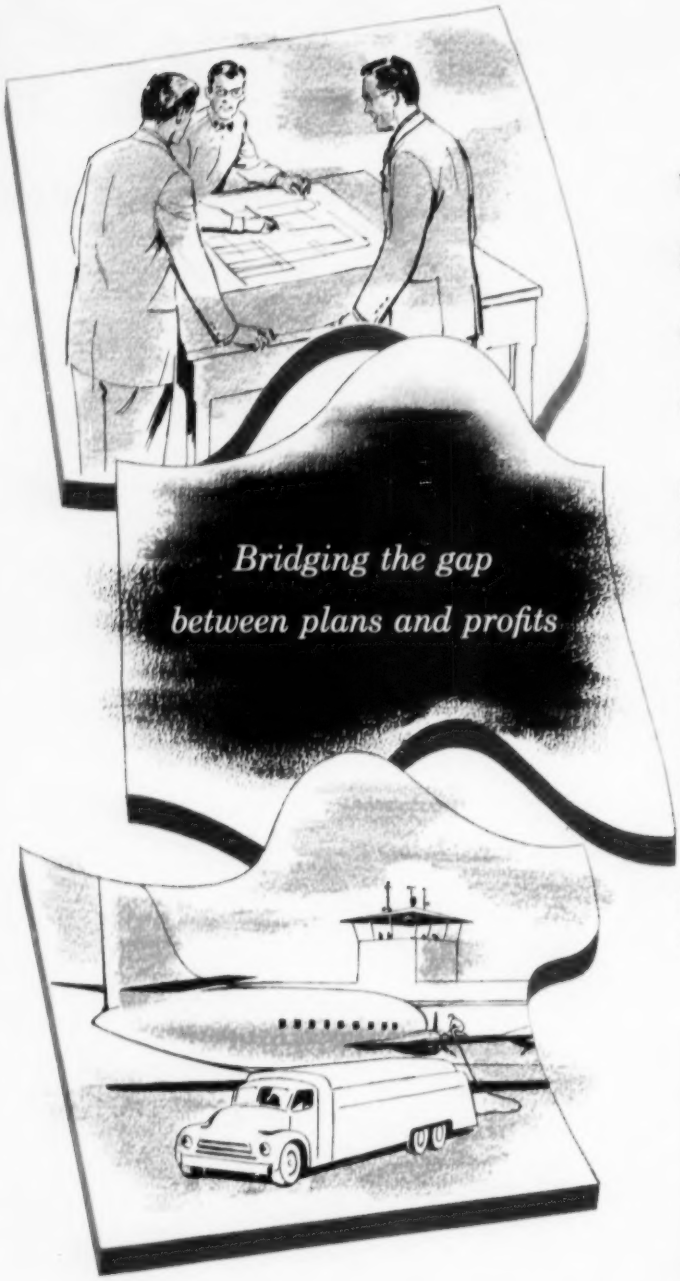

WORLD'S LARGEST SOVAFORMER...

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Socony-Mobil Oil Company, Inc. now owns the largest commercial Sovaformer ever built. This giant unit, rated at 20,000 barrels-per-stream-day, produces high octane motor fuel and aviation gasoline to meet the increasing demands of today's high compression engines.

The project—with a construction period of only 12 months—is another example of how The Fluor Corporation, Ltd. swiftly turns management planning into profitable production. Whether your plans call for a complete processing plant or a single unit, it will pay you to get acquainted with Fluor.

The Sovaformer covers an area of 120,000 square feet. Consisting of a catalytic reformer section and a naphtha pretreater section, the Sovaformer was Fluor's second multi-million dollar project completed at Socony Mobil's Paulsboro, New Jersey refinery in the past three years.

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for the Petroleum, Chemical and Power Industries

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Volume 35, No. 11 November, 1956

PETROLEUM
REFINER
REFINING | PETROCHEMICALS | NATURAL GASOLINE

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A Quick Look

at This Issue

These handy digests permit checking ☑ those articles you want to read first.

RECIPROCATING COMPRESSOR SPECIAL REPORT

☐ **Introduction to Principles . . .** Compressors are manufactured in a wide range of types, ranges and capacities. Be sure you have the right type for your job . . . turn to **Page 120.**

☐ **Mechanical Design . . .** To select a compressor you need to know their design characteristics. This article shows designs used for various operating conditions. For complete details, turn to **Page 124.**

☐ **Performance Characteristics . . .** This article will give you a complete method for determining whether your compressor is operating at its optimum design conditions. Turn to **Page 129.**

☐ **Installation, Operation and Maintenance . . .** Here is a complete manual on how to install, operate and maintain a reciprocating compressor. This article is written for practical men and gives timely methods, based on years of practical experience. Turn to **Page 137.**

☐ **Compressor Trouble Shooting . . .** Is there a compressor doctor in the house? If you are having trouble in diagnosing compressor ailments this should help you. Turn to **Page 149.**

☐ **Is Your Distillation Column in Balance? . . .** Here is a non-mathematical, down-to-earth discussion by an expert on this subject. He explains the economic factors as well as what actually happens within the tower. He also tells how to set up control systems to insure balance. Since a great number of refining operations involve installation, you will want to review this article starting on **Page 151.**

☐ **Do Design Models Pay Out? . . .** Fluor has justified them on the savings in design and drafting alone. They are using three different types of models and have built up a staff of 20 model makers to handle the load. For what they're getting out of models, turn to **Page 161.**

Please Turn Page ➡

A Quick Look at This Issue . . .

☐ **Use This Method for Drainage Time of Bubble-Cap Columns . . .** and you can save yourself time and a lot of trouble. This is the easy way to know the correct time required for the liquid to drain from the tower regardless of the number of trays. This will help you in scheduling shutdown and turnaround times. You need only a minimum amount of information to make these calculations. See **Page 165.**

☐ **Find Absolute Viscosity by Nomograph . . .** Using this nomograph you can quickly determine viscosity of any hydrocarbon for a wide range of temperatures. Absolute viscosities determined are well within the range of engineering accuracy. Add this useful nomograph to your work book, turn to **Page 169.**

☐ **Here's the Complete Story on Pentaerythritol . . .** The end uses of all polyhydric alcohols are compared to PE—also, process variables that effect yield and quality of PE are explained. For the latest word on this growth petrochemical of the 50's, turn to **Page 171.**

☐ **Are Explosion-Proof Motors Necessary? . . .** If your motor costs are running high, a material reduction in expense can be had by using ordinary hazard motors. Here is a way to design new units or change existing areas so the need for explosion-proof motors is eliminated. For complete details, turn to **Page 180.**

☐ **It Pays To Organize . . .** Individual corrosion engineers can solve many problems, but major corrosion problems need company-wide cooperation. Here's how one company is making its corrosion organization pay off. Turn to **Page 183.**

☐ **Which Steel For High Temperature Piping . . .** Are your new high temperature processes utilizing the best material for piping? Here is a look at some of the most commonly used metals, showing the effect of high temperature. For complete details, turn to **Page 185.**

☐ **Use This Nomograph for P-V-T Properties of Liquid N-Butane . . .** and you'll save time while sacrificing no accuracy. This one's prepared by the old master, Dale S. Davis, himself. Whether you are at high or low pressures, or high or low temperatures, all the information is here for you on one page. You'll put this one in your notebook pronto after you see **Page 190.**

☐ **How to Maintain and Inspect Lead Linings . . .** Where corrosion is very severe, lead lining is often the most economical solution. However, its economic advantage is soon lost if operating conditions or mechanical abuse continually remove the lead's normally protective film. Here are some pointers to remember on increasing the service life of lead linings. Turn to **Page 191.**

☐ **Simplify Boiler Water Treatment . . .** Ever wonder just why the various treatment chemicals are used in boiler feedwater? What are the effects of pH, dissolved oxygen, carbon dioxide, alkalinity, and total dissolved solids on boiler operation? The limits of these variables are discussed for various operating pressures. Examples of treatment programs are given. Check your feedwater treatment now by turning to **Page 193.**

☐ **Fuel Gas Analysis by Chromatography? . . .** It's a more accurate method than Orsat and cheaper than mass spectrometry. This is the first report on the use of chromatography in fuel gas analysis. You can improve your analyses by turning to **Page 197.**

☐ **New Process for Removing Reformer Feed Stock Sulfur . . .** Using acid-treating plus electrostatic mixing and coagulation, this process effects almost complete removal of sulfur in reformer feed stocks. Investment and operating costs are far less than hydrodesulfurization. For complete details, turn to **Page 202.**

☐ **New Method for Vapor Pressure . . .** For the hexanes-plus fraction of natural gasoline, this method is quicker and more accurate than usual methods. And it takes only a one milliliter sample. To see how it works and how its results have been checked, turn to **Page 205.**

☐ **Will Atomic Energy Replace Oil? . . .** Here is what one of the nation's top oil leaders has to say about oil's future in the atomic age. For one of the most timely and informative reports to date on the effect atomic energy will have on future demand for residual fuels, natural gas and other heating fuels, plus a provocative look into the future of the atom, turn to **Page 118.**

☐ **Are Your Communications Showing? . . .** Only in recent years has management been able to take leadership in employe communications without violating the law. Unions have never had these shackles, thus are now a direct competitor in this vital field of employe relations. Here is an information-packed discussion that offers many valuable ways to improve company communications. Turn to **Page 244.**

☐ **Petrofina Expands Refinery Operations on Three Continents . . .** Here is another of Petroleum Refiner's series on the refining industry's remarkable expansion since World War II. This report of Petrofina's recovery from the devastation of World War II reflects the amazing recuperative powers of Europe's oil industry. For the complete report on Petrofina's recovery from chaos and subsequent expansion on three continents, turn to **Page 256.**

☐ **What's Happening . . .** Busy readers appreciate the complete and concise method PETROLEUM REFINER reports the news. For a quick rundown of events that made news in the industry, turn to **Page 265.**

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WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

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Here Is Must Reading

PETROCHEMICAL PROCESS and demand patterns are changing so rapidly that a continuous watch must be maintained for new developments. And here PETROLEUM REFINER is your eyes and ears, because a full report will appear in our Fourth Petrochemical Issue slated for December. An economic outlook to show you what's ahead is followed by process descriptions covering use of LPG and oxygen as raw materials, a basic discussion of the OXO process and another showing use of the Fischer-Tropsch process for liquid fuels manufacture. Synthetic rubber is not forgotten. New processing tools of superfractionation and low temperature are included. Then there are articles dealing with the newest petrochemical intermediate, acrolein, as well as a topnotch and authoritative summary on petroleum-derived synthetic detergents. Finally, the influence of marketing problems on petrochemical plant design is discussed. Truly if petrochemicals is your field, then PR for December should be listed high on your MUST reading.

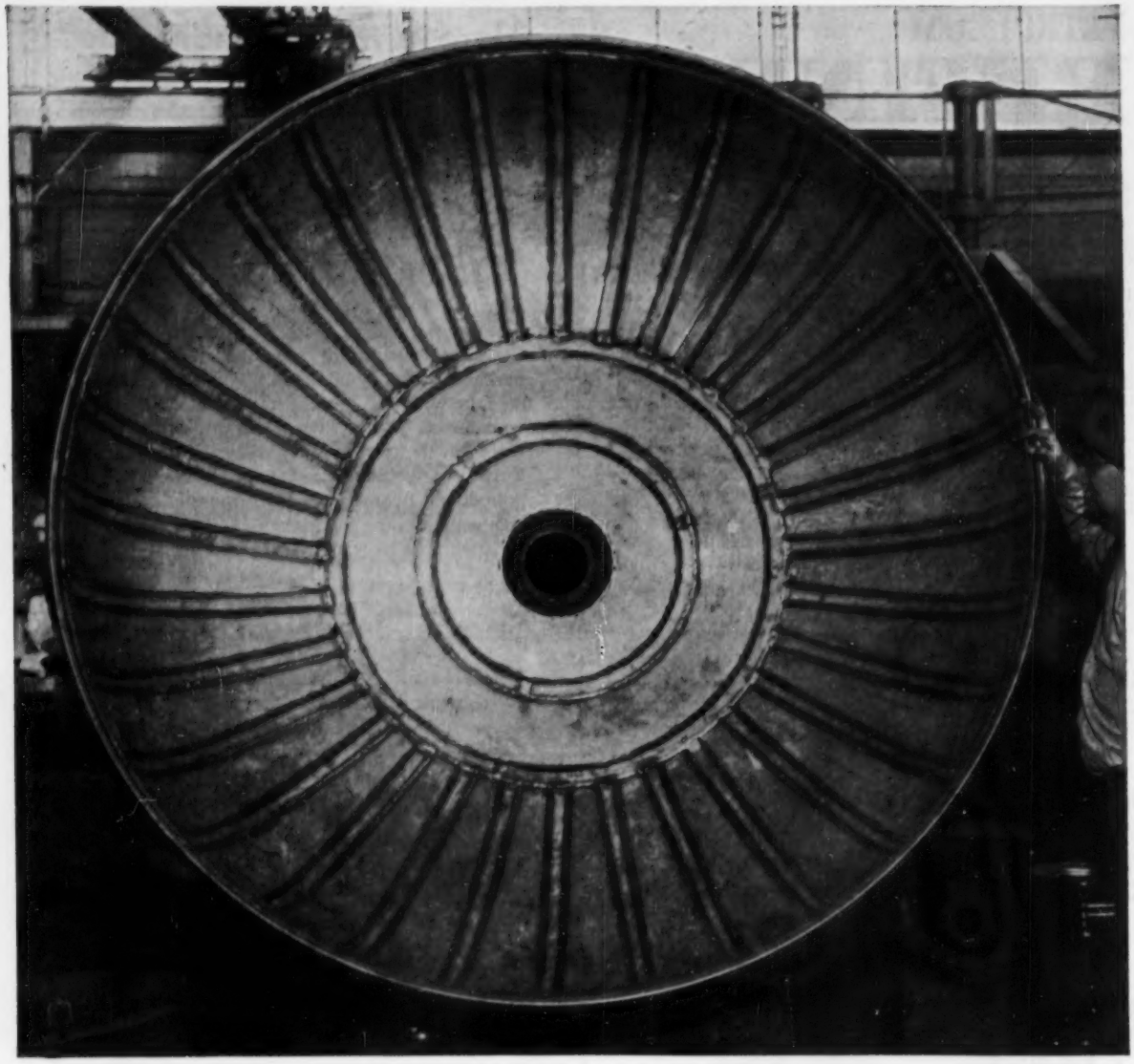
Special January Dividend

FOLLOWING immediately behind our Annual Petrochemical Issue (see item above) as well as Santa Claus will be PR's Fourth Annual Maintenance Issue slated for January. No one has to tell management how maintenance costs relate to the over-all plant expenditure picture. This is the big reason that many of them are so interested they will not want to miss this Maintenance special. Article after article therein will show *how to change cost dollars into profits.* Graphic treatment of all phases of the industry—refining, petrochemicals, and natural gasoline—will be included in the content. The REFINER, of course, for many years, on a month-to-month basis, has been featuring articles dealing with maintenance. But this January issue will be a big package containing articles especially valuable to (1) those actually engaged in or supervising maintenance work, and (2) company higher-ups who realize the problems—cost and others—involved in maintenance. For the first group, for example: what protective coatings can do and ways to improve instrument maintenance; for the second, a new survey which relates maintenance costs to replacement values. Special reading dividends from this January issue will be quite worthwhile, we assure you.

Pat Sent and Accepted!

WE DON'T always do this well, but when we do it's grand to have someone take note and send an epistolary pat on the back. The letter, from Standard of California's Robert R. Ridgway whose discussion of compressor installation, maintenance and operation appears on Page 137 of this issue, reads as follows:

"You amazing people! Thirteen galleys of proof and no mistakes! The only change to be made is on Galley 180. I wrote 'when' and I meant to say 'where.' Thank you for your beautiful work."



FLYING SAUCER?

Could be . . . considering the craftmanship

This skillfully fabricated head is part of an absorber tower for the production of polyethylene. Of carbon steel with a carefully applied Hastelloy lining, it has proved very resistant to the highly corrosive reactions of gaseous chemicals under conditions of high temperature and pressure. For long-lasting equipment under exacting service conditions, Graver is a reliable source of skilled craftmanship.

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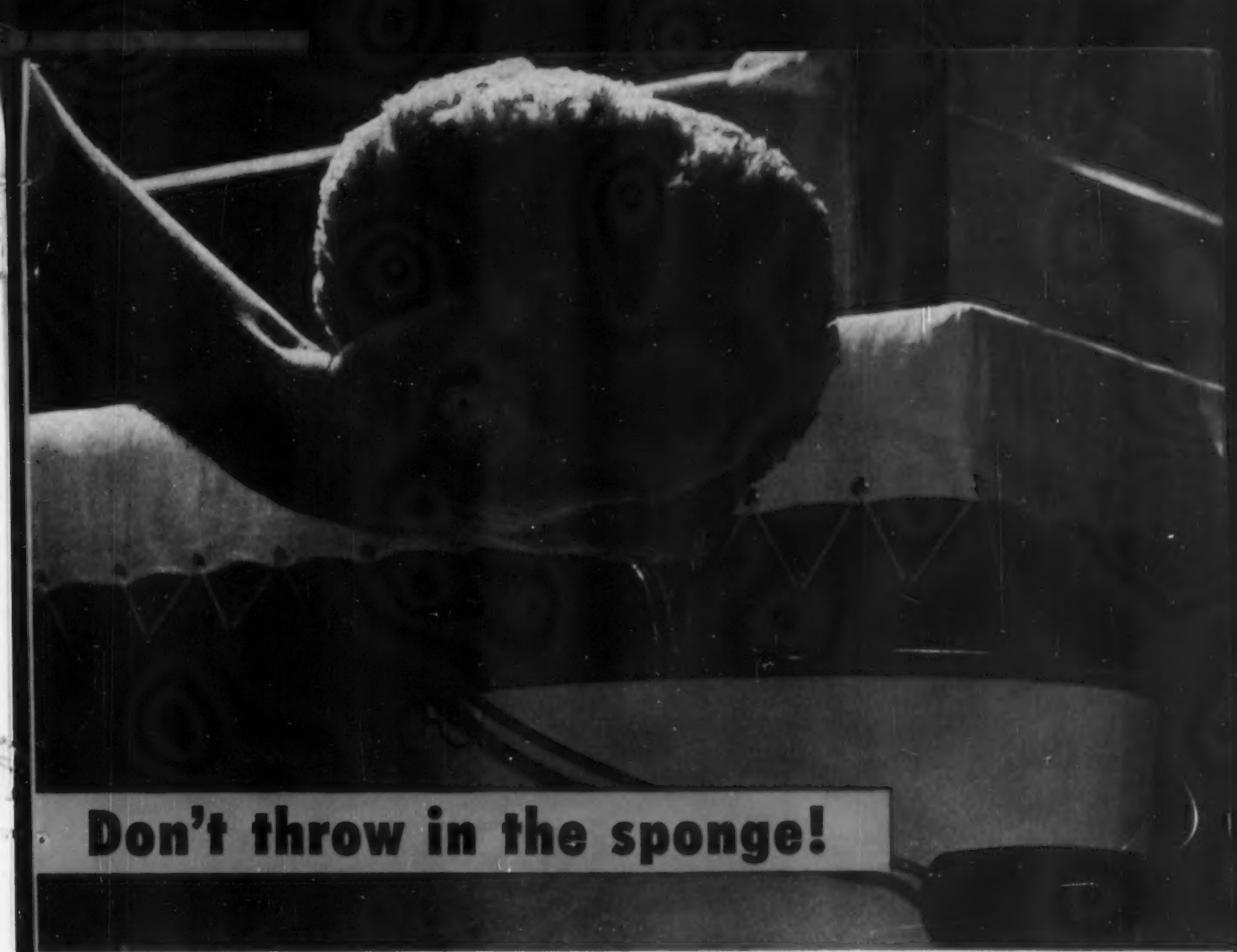

Don't throw in the sponge!

● We're the first to admit that it is no easy job to specify and buy the thousands of products needed to operate a modern refinery or petrochemical plant. But before you throw in the sponge and retire to that South Sea island, call "Oilwell."

We've been living with procurement problems such as yours for 92 years. Skilled specialists are available who spend all their time working with men like you. Completely stocked warehouses are strategically located so that you can get the item you want direct from our stocks—in a hurry.

Why not call "Oilwell" the next time you have a problem?

Complete warehouse system—Well stocked warehouses are conveniently located to serve the important refining centers. Inquiries are given prompt attention and deliveries are made quickly to meet your emergency requirements.

Lower inventory investments—You can cut your own warehouse stocks to a minimum, reduce obsolescence and get a wider selection of materials, sizes and brand names from "Oilwell's" complete inventories.

Experienced personnel—"Oilwell" refinery specialists, having been trained in refining and petrochemical plants, understand your material and service problems and can give you the service you require.

Quality products — "Oilwell" stocks include the best known brand names in equipment and materials designed and approved for refinery operations. When it comes from "Oilwell," you know it will meet your specifications.

92 Years of experience—From almost the beginning of the petroleum industry, "Oilwell" has worked with the men engaged in drilling and production. Our goal is to extend the same prompt, dependable and complete service to those responsible for Refining and Petrochemical operations.

These famous products are sold by "Oilwell"

Bridgeport Brass	Taylor-Forge
Catawissa	Thermoid
Johns-Manville	Vogt
Lunkenheimer	Walworth
Manning, Maxwell & Moore	Watson-Stillman
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and many others

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"OILWELL"

TRADE MARK

UNITED STATES STEEL

End uncertainty in getting the longest tube life per dollar:

. . . *ask the experts!*

WHATEVER your high-temperature steel problems—heat, pressure, corrosion, oxidation—there's always one tube steel among the Timken Company's 24 different high-temperature analyses that will do the best job. One that will give you the maximum service per dollar and cost per year of required service—the best life/cost ratio.

To find this *one,* right analysis, *ask the experts!*—the metallurgists of The Timken Roller Bearing Company.

These experts are recognized authorities on high-temperature steels, have been for over twenty years. And they're ready to put their experience to work for you. They'll study your particular requirements, recommend the one tube steel to most satisfactorily and economically meet them. Result: you get the longest tube life per dollar.

And you can be assured of uniform high quality in the Timken® steel you get. For the Timken Company controls and guards steel quality from the furnace to final inspection.

Call on Timken Company metallurgists for understanding help in solving your tube steel problems. End uncertainty. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

SICROMO-7

Suggested as a subsitute for steels of the 5.0 per cent chromium type for applications which require increased resistance to corrosion by hot petroleum products.

23 TIMKEN® STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti	18-8 Cb	

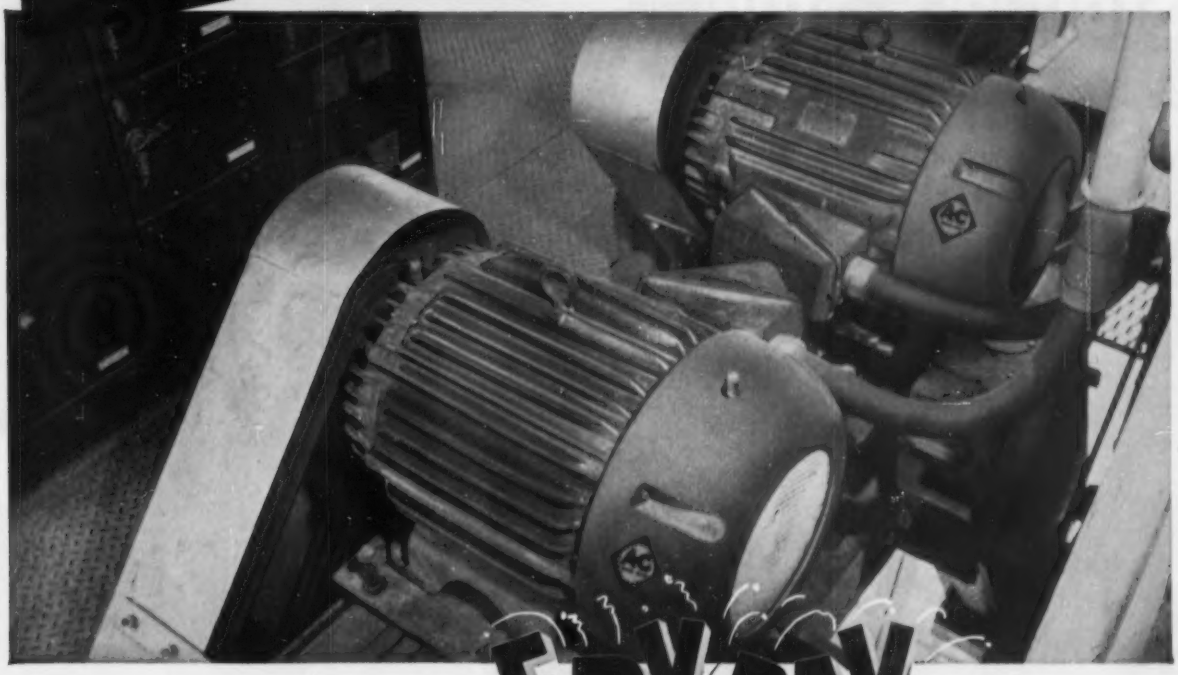
**Not available as seamless tubing at the present time.*

General view of the Timken Company metallographic laboratory where many analyses of steels are viewed under high-power microscopes.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**



No Day is FRYDAY

with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result—you expect and get longer motor life.

The engineered partner of A-C motors is Allis-Chalmers control.

Get Complete Information

As a new machinery component or as replacement, specify Allis-Chalmers. Discuss your particular application with your nearby A-C distributor, A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

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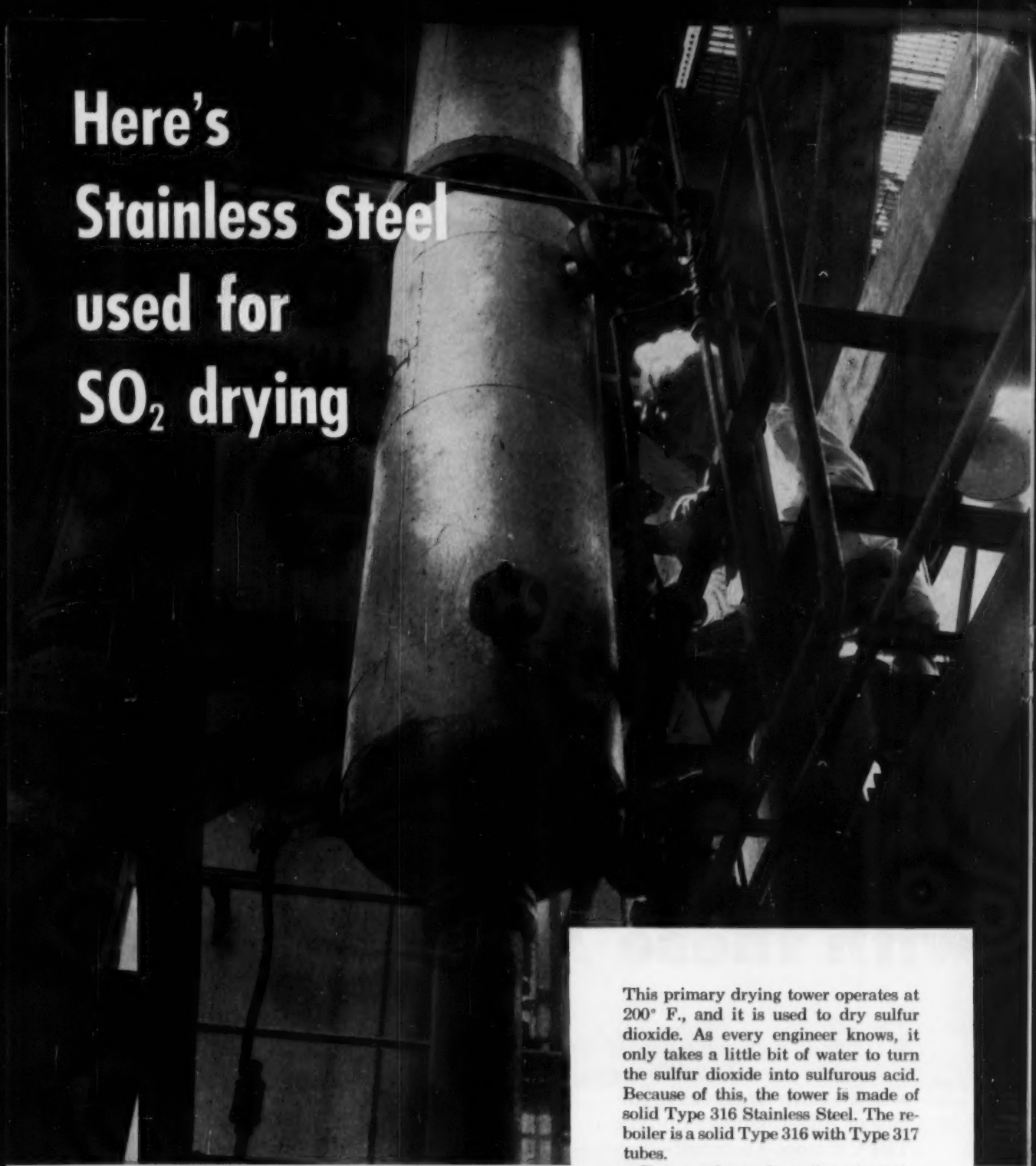

Here's Stainless Steel used for SO_2 drying

Continental Oil Refinery No. 3, Lake Charles, Louisiana

This primary drying tower operates at 200° F., and it is used to dry sulfur dioxide. As every engineer knows, it only takes a little bit of water to turn the sulfur dioxide into sulfurous acid. Because of this, the tower is made of solid Type 316 Stainless Steel. The reboiler is a solid Type 316 with Type 317 tubes.

Every refinery is a showplace for Stainless Steel, because no other metal combines so many desirable properties. When *designing* with Stainless Steel, remember that United States Steel can furnish a greater variety of grades, types, sizes and finishes of Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
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USS STAINLESS STEEL

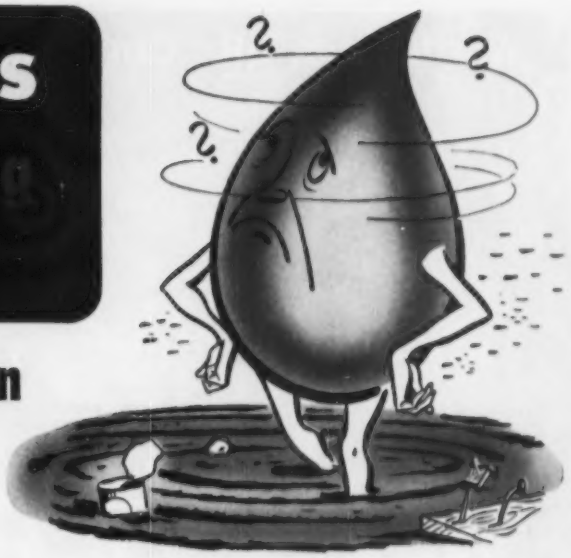
SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE SPECIAL SECTIONS

UNITED STATES STEEL

ALLIS-CHALMERS

Water Conditioning

ON THE JOB



Reporter finds solution to wide range of water problems

•Raw water is seldom suitable to meet specific requirements of the job. It usually needs some type of conditioning — best determined by a specialist. Here are typical examples of Allis-Chalmers water conditioning experience, equipment and chemicals in use.

Saved $22,000 First Year

Kansas—A chemical company plagued by high steam costs. Their boiler make-up water contained a high solids concentration, requiring a high blowdown rate.

After careful analysis of their problems, an Allis-Chalmers water conditioning engineer recommended Allis-Chalmers Anti-Foam. Use of this chemical resulted in increasing the solids concentration of the boiler water without carry-over. This, in turn, reduced the percentage of blowdown required.

Using A-C Anti-Foam, the company conservatively estimated first year savings of $22,000 in heat, water and chemicals.

* * *

Replacement of Condensate Return Lines Reduced to Practically Zero

Wisconsin—Here in one of the largest malt producing mills, several million pounds of steam are used daily for drying malt.

A special crew used to work all day every day doing nothing but replacing corroded condensate return lines. This, of course, was extremely costly.

Seven years ago, Allis-Chalmers water conditioning engineers were called in. Use of Allis-Chalmers No. 160 return line corrosion inhibitor was suggested.

Piping failures were reduced to the point where they only occur occasionally, and the maintenance crew has been assigned to other duties.

The Customer Is Always Right . . . Well, Most of the Time

East Coast — This plant had been using internal treatment of its boiler water. Chemical costs seemed excessive to management. After analyzing their own situation, they requested bids on a deionizer for treating makeup.

Instead of merely submitting a bid on the equipment specified, Allis-Chalmers engineers analyzed the water and the plant problem. This analysis showed that plant needs were such that a deionizer wasn't needed.

All that was needed was a de-alkalizer. Result: a savings of thousands of dollars.

* * *

The Case of the Dirty Dishes . . . or Don't Blame the Poor Dishwasher

Midwest — A harried plant cafeteria manager placed a frantic call to Allis-Chalmers water conditioning experts. Something was wrong. Glasses were spotty and plates had to be individually wiped off before they could be used. The grumbles were growing in the dining room . . . costs rising in the kitchen. His brand new $30,000 dishwasher wasn't getting the dishes clean, and the supplier of the dishwashing machine said the trouble was caused by the water.

The only trouble with that theory was that he had just installed a water softener the year before. The Allis-Chalmers water conditioning engineer examined the dishes coming out of the water and then asked to see the water softener. The problem was obviously hard water. The unit seemed to be in good working order and the tag indicated the softener had been recharged the previous day.

The maintenance man was called and asked to recharge the softener while an A-C engineer stood by. He went through all the steps—all but one, that is. He failed to close the bypass valve above the softener and practically none of the water went through the softener. It was then learned the operator was new and had not been properly trained.

Needless to say, the maintenance man is now an expert at operating the system, and everyone is pleased with the sparkling dishes.

Moral: A-C engineer's service covers the water front.

Expert Saves Steam for Drop Forge User

North Central — An Allis-Chalmers water conditioning engineer was called in by a manufacturer to supply water conditioning for makeup water. In checking the plant, here's what he found:

A large number of steam-operated drop forges are used by this company. The steam picked up oil from the pistons of the forge and was too contaminated for further use. It was dumped to waste.

He recommended installation of condensate oil removal filters. This was done and today practically all condensate is recovered. Makeup and water conditioning requirements are greatly reduced.

Problems Solved

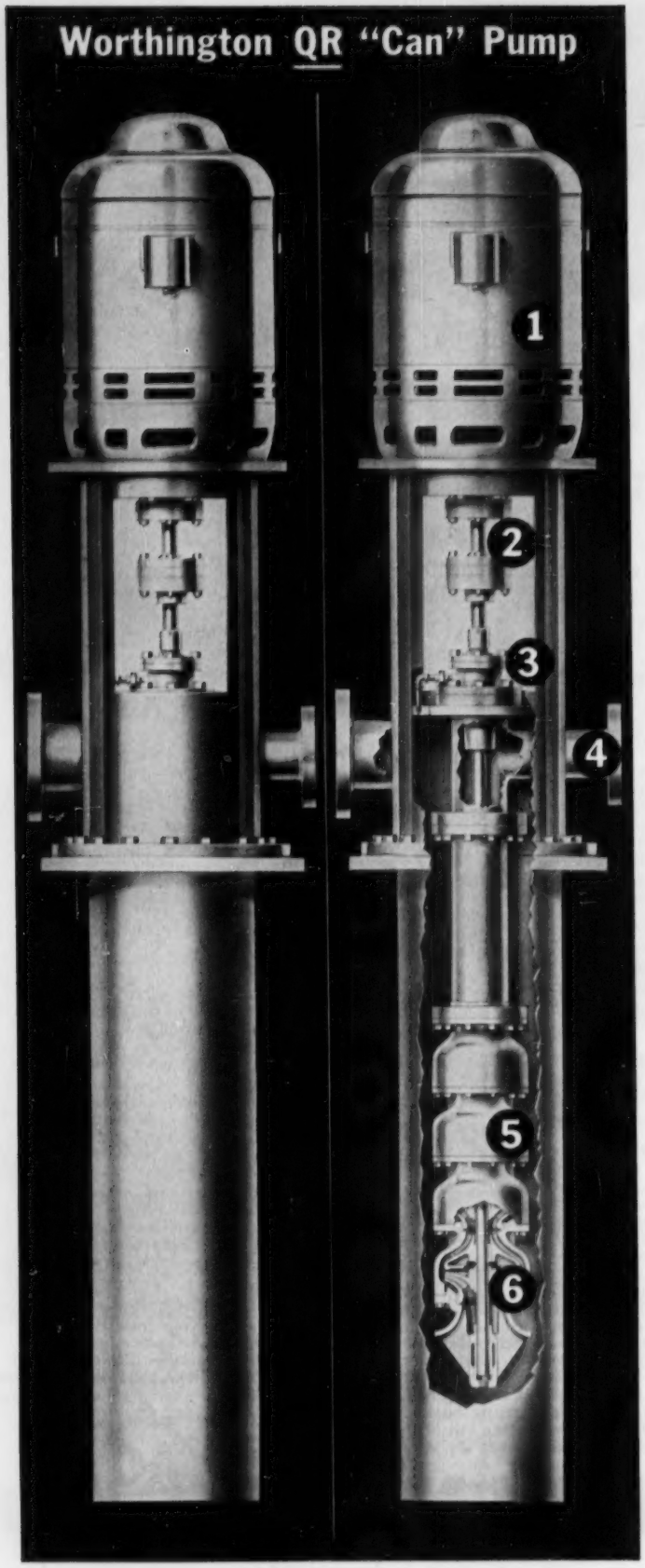
For an answer to your industrial water problem, call the A-C office nearest you or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

WATER CONDITIONING • CHEMICALS, EQUIPMENT, SERVICE • FOR OVER 25 YEARS

A-C ALLIS-CHALMERS

A-5237



WE'VE LICKED THESE REFINERY PUMP PROBLEMS:

Space
NPSH
Vibration

The toughest problems in vertical process pumps have been licked in the Worthington QR. Vertical construction requires minimum NPSH and space. Smoothest performance is assured by proper and conservative design of all running parts and nozzle heads. The quiet performance and long operating life of the QR are unequaled.

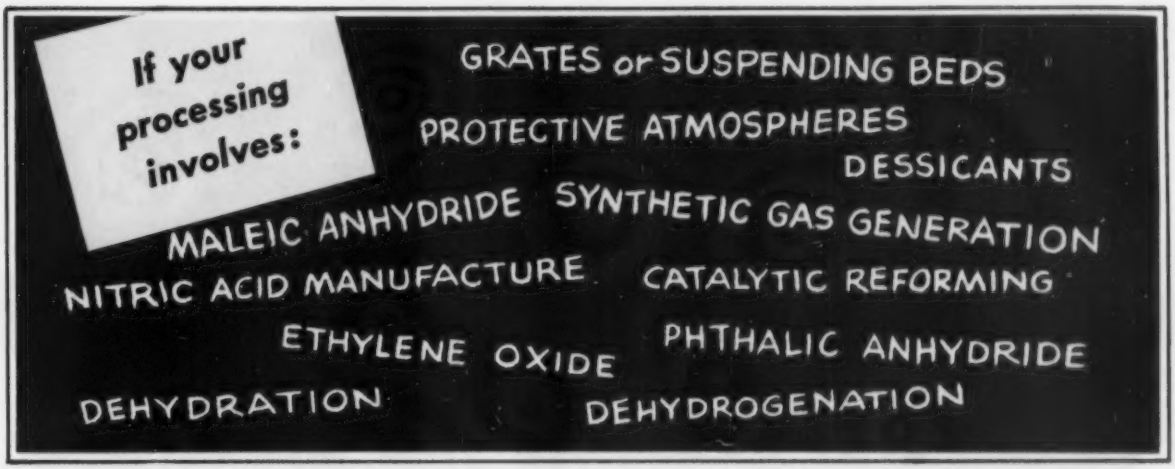
1. Driver can be a vertical solid shaft motor, vertical turbine, or right angle gear with shaft extension threaded and keyed for driver-half coupling.
2. Worthington rigid adjustable coupling. Spacer type shown furnished with mechanical seals to facilitate maintenance.
3. Available with mechanical seals or conventional box for packing with or without cooling.
4. Nozzle head and suction tank of fabricated steel.
5. Flanged type bowls of high strength cast iron with enclosed impellers and one piece shaft.
6. First stage impeller and suction bell designed for NPSH requirements.

In every point of operating efficiency, the Worthington QR Vertical Process Pump has proven superior. Talk to your Worthington engineer about your pump requirements. Worthington Corporation, A & SP-Pump Dept., Section C.6.2, Harrison, N. J.

C6.2

WORTHINGTON

For more data on advertised products, use Readers' Service Cards, last page.



You can benefit by using ALUNDUM* catalyst carriers

More and more chemical engineers are finding in Norton ALUNDUM catalyst carriers the R$_x$'s they need for faster, better, lower cost production in a wide range of processing.

These fused alumina carriers are characterized by excellent mechanical, thermal and chemical stability. They have high resistance to abrasion and erosion, and their low density is useful for packing and filling applications. Catalytically, they are crystalline in nature and are produced in two surface area types: low and intermediate. Intermediate surface area carriers are subdivided into types A, B, and C, with varying characteristics.

TYPICAL CHEMICAL ANALYSES (%'s)

	LOW SURFACE AREA	INTERMEDIATE SURFACE AREA
Al_2O_3	89.4-76.6	77.0
SiO_2	9.3-16.8	21.2
Fe_2O_3	0.5 – 1.3	0.2
MgO	0.1 – 0.6	0.4
CaO	0.1 – 0.8	
Na_2O	0.3 – 0.4	0.5
K_2O	0.1 – 1.0	0.2
TiO_2	0.2 – 2.5	0.5

PHYSICAL PROPERTIES

	Porosity	Water Absorption	Bulk Density	Vol. Bulk Density	Crystal Structure	Surface Area
Low Surface Area	40-50%	20-25%	1.90-2.10 gr/cc	65-80 lbs/ft³	Alpha Alumina	Less than 1m²/gram
Intermediate Surface Area Type A	50-55%	28-30%	1.65-1.70 gr/cc	58 lbs/ft³ (app)	Alpha, Gamma Alumina-chiefly Gamma	60-70m²/gram
Type B	50-55%	28-30%	1.65-1.70 gr/cc	60 lbs/ft³ (app)	Quartz, Alpha, Kappa, Delta Alumina-	20-30m²/gram
Type C	50-55%	28-30%	1.65-1.70 gr/cc	62 lbs/ft³ (app)	Alpha Alumina and Mullite	5-10m²/gram

Shapes and Sizes

Spheres: (Low surface area) 3/16"-1" diam; (Intermediate surface area) 1/4"-1/2" diam. *Pellets:* (All carriers) 1/8" x 1/8"-1/2" x 1/2". *Rings:* (All carriers) 1/8" x 1/4" x 3/8" O.D.-1" x 1 1/2" x 1 1/2" O.D.

Typical Applications

Low Surface Area Carriers: phthalic anhydride, maleic anhydride, ethylene oxide, protective atmospheres, synthetic gas generation, grates or suspending beds for active catalysts.

Intermediate Surface Area Carriers: catalytic reforming, dehydrogenation, dehydration, sulfuric acid manufacture, nitric acid manufacture, dessicants.

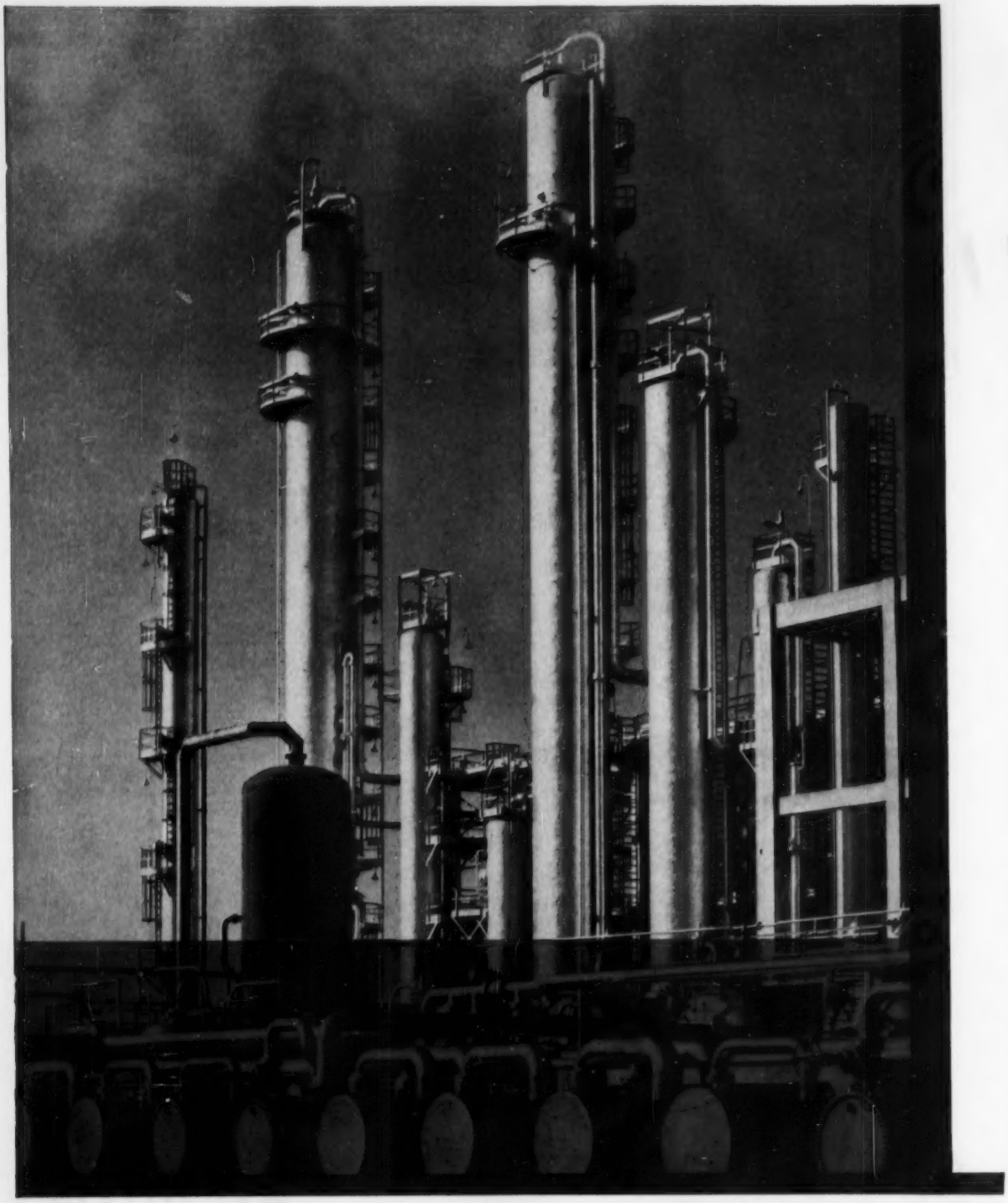
Get More Facts

on how Norton ALUNDUM catalyst carriers are *engineered and prescribed* to give you the most effective combination of physical, thermal, chemical and electrical properties. Learn how they can improve and economize your processing. Call in your Norton Refractories Engineer, or write, mentioning your specific requirements, to NORTON COMPANY, 470 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Canada.

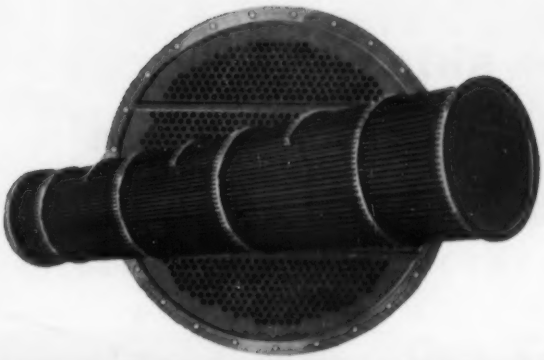
NORTON
REFRACTORIES
Engineered... Rx... Prescribed
Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

for more data on advertised products, use Readers' Service Cards, last page.



FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



For dependable "on-stream" performance . . .
retube your exchangers with

PHELPS DODGE HEAT EXCHANGER TUBES!

Wide selection of copper-base alloys for every type of application—including bi-metal combinations.

Complete warehouse stocks maintained at Houston, Texas; Tulsa, Okla.; Los Angeles, Cal.; Chicago, Ill.; and Bayway, N. J.

Expert assistance in solving your tube corrosion problems.

Specify Phelps Dodge . . . One of the largest suppliers of tubes to manufacturers of heat exchangers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

He skipped the same 2 valves again today

Both are still in adjustment. Still no leaks, not even at the shank! Both are OIC plug valves. If he's curious enough to dismantle one, he'll see the OIC gland and O-ring construction that saves him time and cussing. It's different from other plug valves he's seen.

Three efficient seals prevent shank leakage on OIC plug valves. Concentric grooves machined into the gland liner form a "labyrinth" seal. The liner also retains an O-ring in contact with the plug's top face for a second positive seal. And resilient packing between gland and gland liner forms the third seal.

But the maintenance man measures design by *results*. OIC plug valves get his O. K. because they stay in adjustment a long time without leakage. However, if *you* are interested in the exclusive gland design and construction of these OIC plug valves, write for specification literature.

The Ohio Injector Company • Wadsworth, Ohio

OIC VALVES

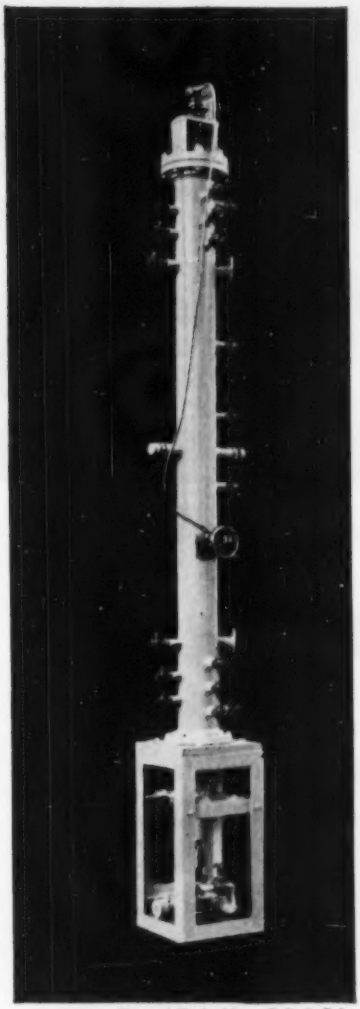
FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES

For more data on advertised products, use Readers' Service Cards, last page.

Turbo-Topics

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXER, a division of
GENERAL AMERICAN TRANSPORTATION CORPORATION



Typical Turbo-Mixer R.D.C. Pilot Column (6" x 8'0") For Research or Design Studies

Pre-Testing Proves that the Turbo-Mixer R.D.C.* Column can solve Your Extraction Problems

Every extraction problem is a bit different. That's why you benefit from Turbo's eight years of research, piloting and industrial scale installations that provide a background of experience applicable to your problems.

Even more important, our laboratory is completely equipped to make specimen runs on your materials and develop reliable plant scale design. Your engineers are invited to observe these laboratory runs. Pilot scale equipment can be built for development studies at your own plant, if you so desire.

The R.D.C. extractor offers you:

1. ***High Volumetric Efficiency;***
2. ***High Thru-Put Capacity;***
3. ***Simplicity of Construction;***
4. ***Low Power Requirements;***
5. ***Flexibility of Operation.***

Our engineers are at your service for application of the R.D.C. to your extraction problem. For further information and descriptive bulletins, write today.

*Licensed under Shell Development Company Patent

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General Offices: 135 S. La Salle St., Chicago 90, Illinois • Offices in all principal cities

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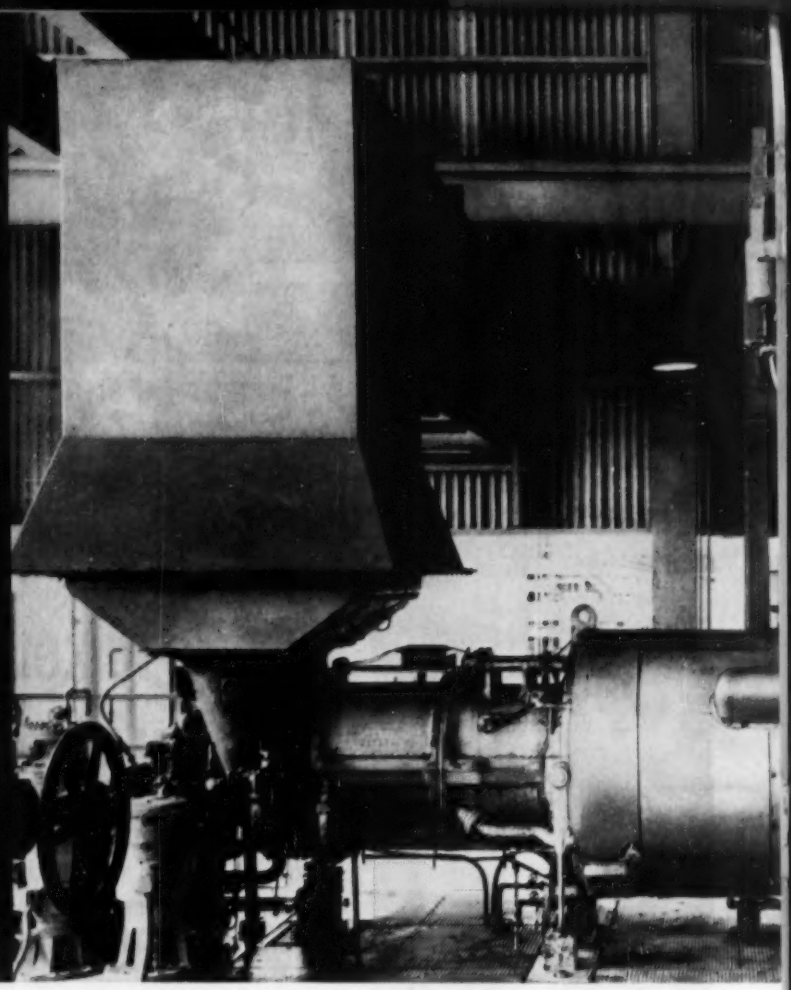
1. RESEARCH AND DEVELOPMENT

2. MANUFACTURING SKILL

3. ENGINEERING SERVICES

4. UNIT RESPONSIBILITY



IN REFINING process, General Electric gas turbine can supply shaft power, exhaust heat, compressed air. Above, turbine drives 3 compressors in tandem.

4 ways General Electric prime-drive systems

When you specify General Electric equipment, these product "added values" help you protect your equipment investment

TWO MAJOR FACTORS affecting your refining costs are unexpected equipment outages and maintenance. Here are four added values, offered by the General Electric Co., to help you protect your vital electrical system against breakdown and excessive maintenance.

1. **RESEARCH AND DEVELOPMENT:** To assure advanced design and construction, General Electric spent over three times as much, per sales dollar, on 1955 research and development than the average of all manufacturing companies.

2. **MANUFACTURING SKILL:** 77 years' experience and a backlog of skilled labor help provide you with more dependable, higher quality, standard or custom-built electrical equipment.

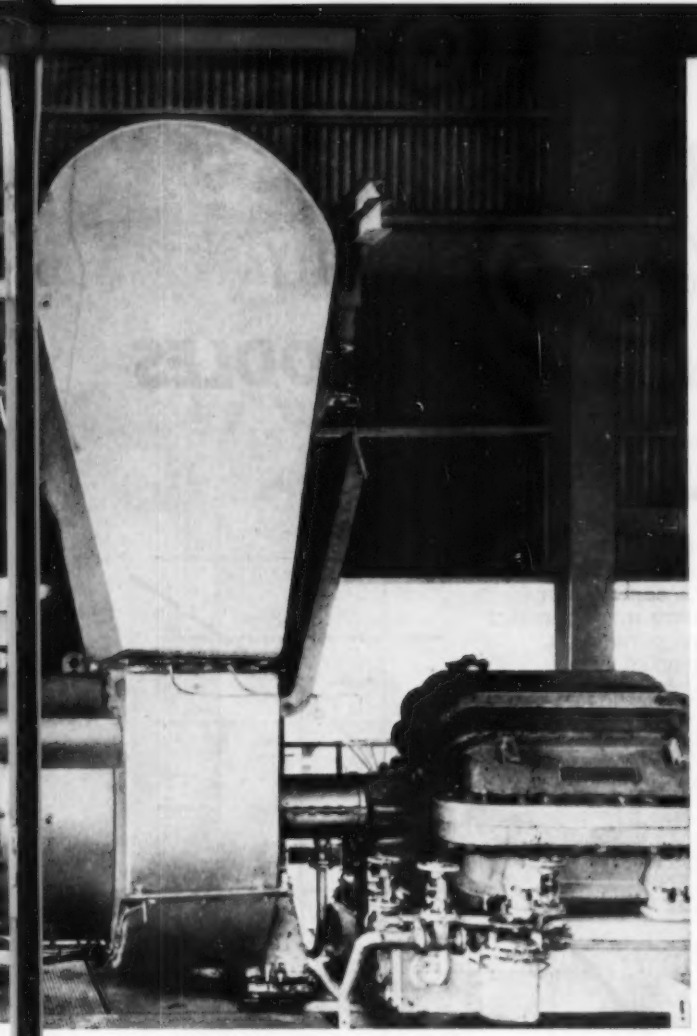
3. **ENGINEERING SERVICES:** 6 engineering services (project co-ordination, application engineering, product development, analytical engineering, installation and service engineering, maintenance service) are available to you and your consultants from planning stages through start-up.

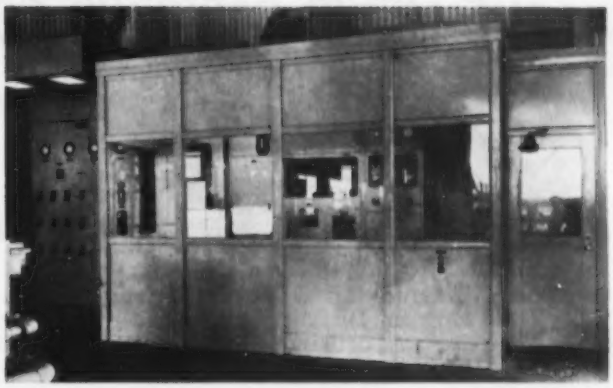
4. **UNIT RESPONSIBILITY:** General Electric provides one-source supply of all the components in your mill's electrical system, plus engineering help in the design, installation and start-up.

CONTACT your nearest General Electric Apparatus Sales Office early in your planning. And write for GED-1966C, "Electrical Equipment for Process Industries" and GED-2244, "Engineering Services" to General Electric Co., Section 681-14, Schenectady 5, New York.

Engineered Electrical Systems for Refineries

GENERAL ELECTRIC





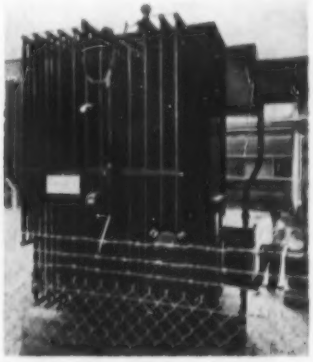
CONTROL for the gas turbine is completely centralized and requires very little actual supervision. After a few manual adjustments, the General Electric gas turbine automatically comes up to speed.

REPLACING six gas compressor drives, this General Electric 4000-hp induction motor application saved space, maintenance costs.

help lower refining costs

COMPACT G-E metal-clad switchgear helps protect and controls drives, requires little floor space, cuts installation costs.

INSTALLED faster because it was shipped completely assembled, 3750-KVA medium transformer supplies power to 4000-hp drive.



PROTECTED against corrosive atmosphere, fan cooled, explosion-proof, hot-oil pump motors need no protective housing.

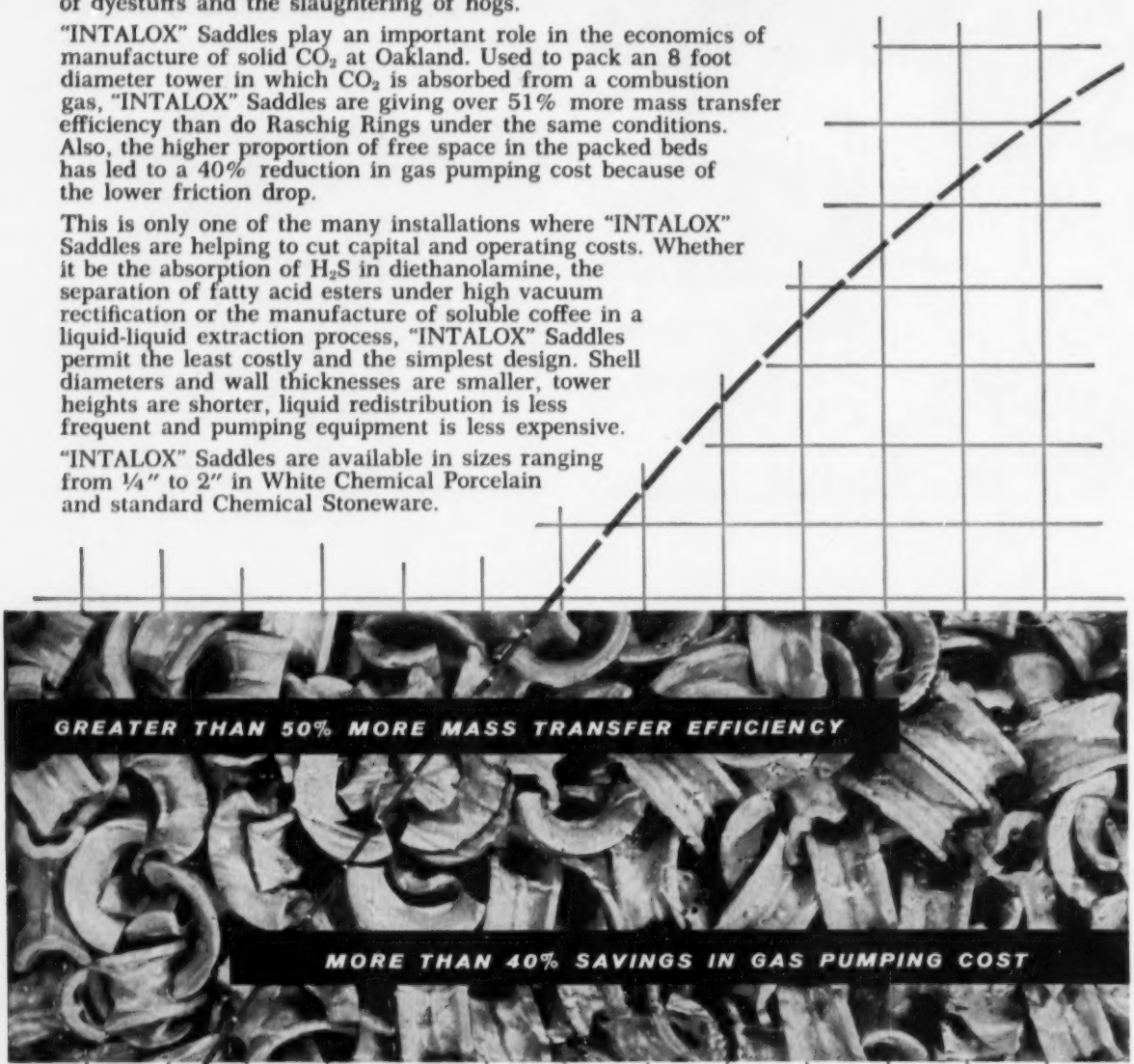
THE LIQUID CARBONIC CORPORATION ABSORBS CO_2 51% MORE EFFICIENTLY WITH *INTALOX SADDLES*

At Oakland, California, The Liquid Carbonic Corporation produces 50 tons per day of dry ice that eventually finds its way into such diverse applications as the refrigeration of ice cream, the production of dyestuffs and the slaughtering of hogs.

"INTALOX" Saddles play an important role in the economics of manufacture of solid CO_2 at Oakland. Used to pack an 8 foot diameter tower in which CO_2 is absorbed from a combustion gas, "INTALOX" Saddles are giving over 51% more mass transfer efficiency than do Raschig Rings under the same conditions. Also, the higher proportion of free space in the packed beds has led to a 40% reduction in gas pumping cost because of the lower friction drop.

This is only one of the many installations where "INTALOX" Saddles are helping to cut capital and operating costs. Whether it be the absorption of H_2S in diethanolamine, the separation of fatty acid esters under high vacuum rectification or the manufacture of soluble coffee in a liquid-liquid extraction process, "INTALOX" Saddles permit the least costly and the simplest design. Shell diameters and wall thicknesses are smaller, tower heights are shorter, liquid redistribution is less frequent and pumping equipment is less expensive.

"INTALOX" Saddles are available in sizes ranging from ¼" to 2" in White Chemical Porcelain and standard Chemical Stoneware.



Write for a copy of Bulletin S-29 filled with technical data on Tower Packings that every engineer can use.

Process Equipment Division

U. S. STONEWARE

AKRON 9, OHIO

"Personally,
I always specify
LEWIN-MATHES
Condenser Tube"

Lewin-Mathes welcomes stiff-necked specifications.

We meet them... because, as COPPER REFINERS, we control the exact composition of every alloy billet we form into condenser tube.

We meet them . . . because, as FABRICATORS, we control every step in the manufacture of Lewin-Mathes Condenser Tube from *raw material to finished product.*

We meet them . . . because, as INTEGRATED SPECIALISTS, we take pride in delivering every foot of Lewin-Mathes Condenser Tube uniform and perfect . . . "tailor-made" to perform better under *your* specific operating conditions.

Lewin-Mathes' mastery over every physical and chemical property of Heat Exchanger Tube can mean important savings for you. Bring your condenser tubing problems to us and see!

Nothing primitive about Lewin-Mathes service facilities. Expert technical and engineering assistance is available to you through 25 strategically-located Branch Offices.

LEWIN MATHES
SAINT LOUIS, MISSOURI
CUPRO-NICKEL CONDENSER TUBE
COPPER AND BRASS TUBE, PIPE AND ROD

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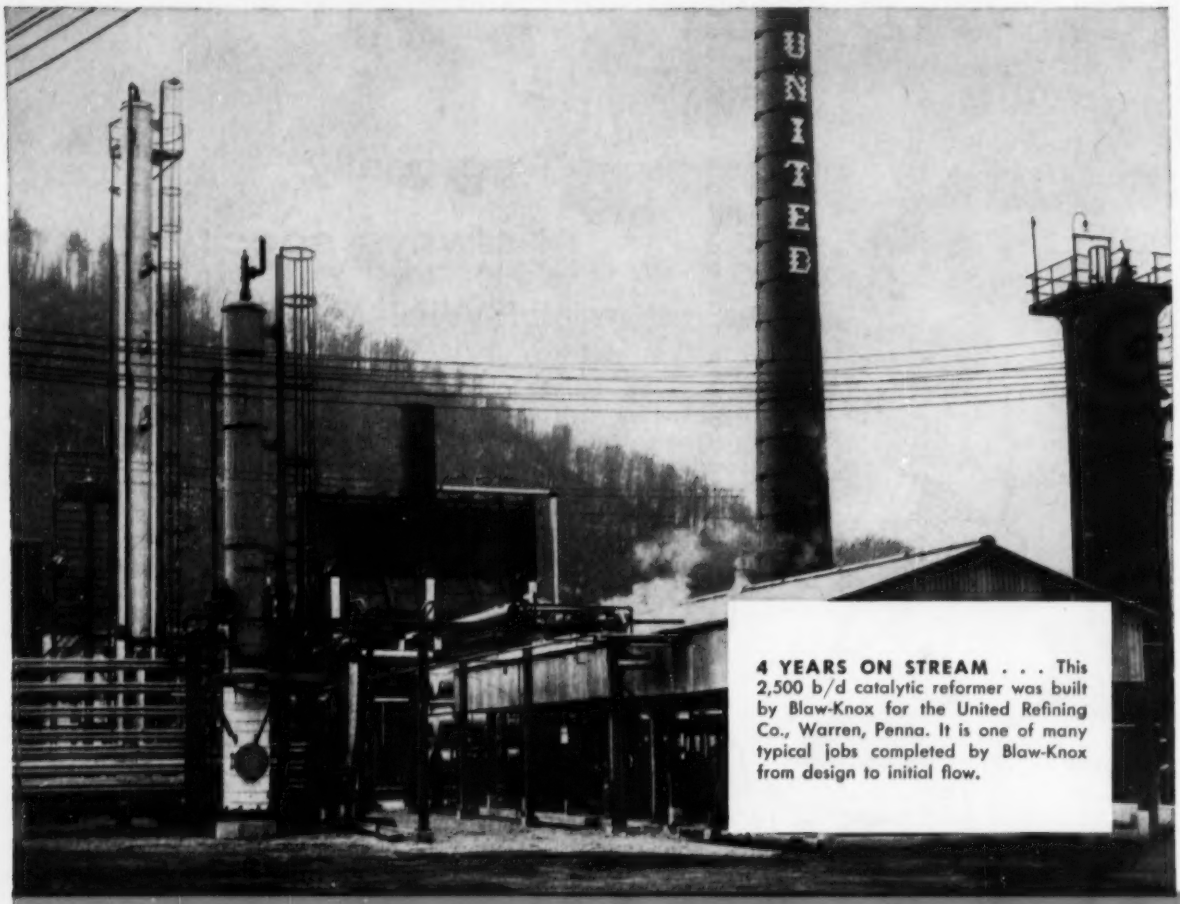
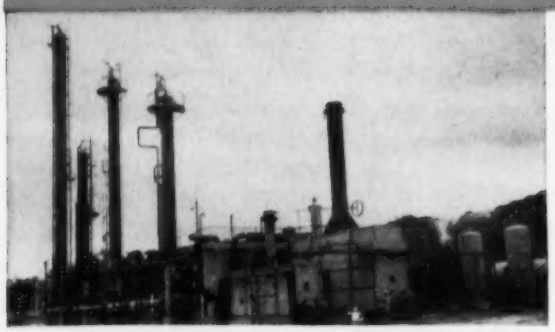


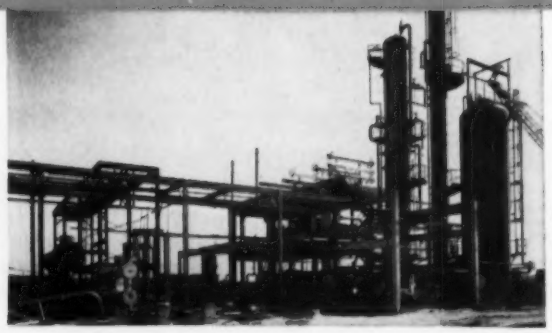
4 YEARS ON STREAM . . . This 2,500 b/d catalytic reformer was built by Blaw-Knox for the United Refining Co., Warren, Penna. It is one of many typical jobs completed by Blaw-Knox from design to initial flow.

BLAW-KNOX has played a major

Here are a few typical units with capacities from 1,000 b/d

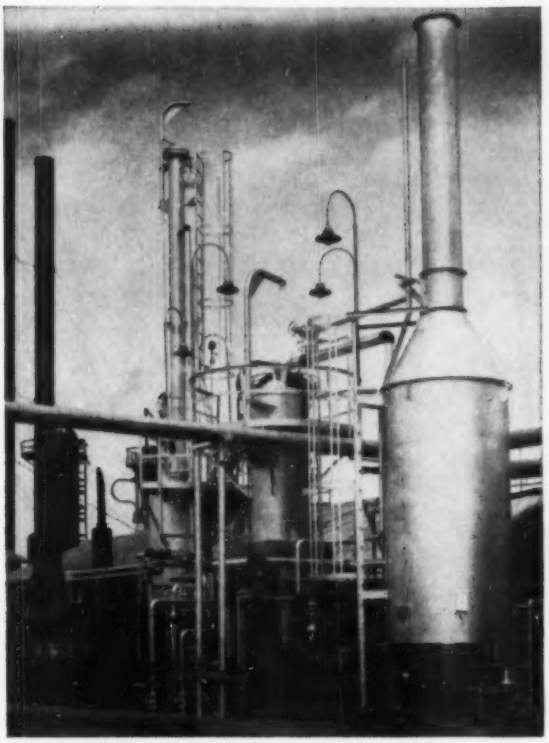


1 YEAR ON STREAM . . . 3,100 b/d reformer, Chinese Petroleum Corp., Kaohsiung, Formosa.

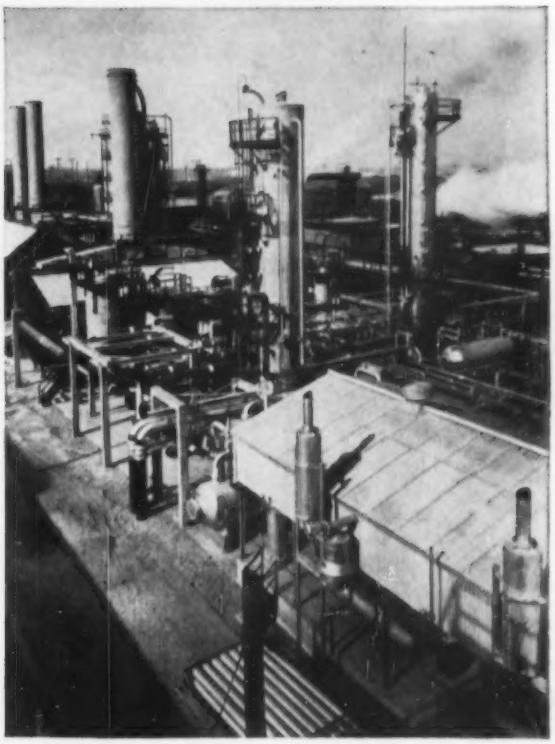


UNDER CONSTRUCTION . . . One of two 6,000 b/d catalytic reformers now being built for Ashland Oil & Refining Co. Also two 15,000 b/d reformers are under construction for Atlantic Refining Co.

For more data on advertised products, use Readers' Service Cards, last page.



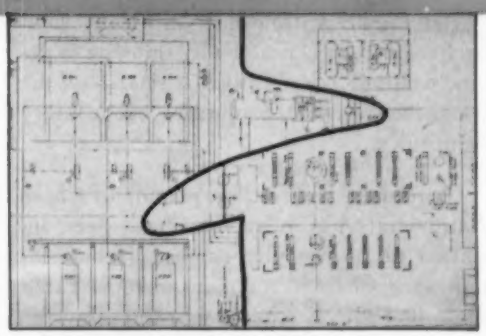
3 YEARS IN OPERATION . . . 1,000 b/d reformer and unifier, Anderson-Prichard Oil Corp., Cyril, Oklahoma.



2 YEARS IN OPERATION . . . 5,500 b/d reformer, Crown Central Petroleum Corp., Pasadena, Texas.

part in catalytic reforming expansion

to 15,000 b/d engineered and built by Blaw-Knox



FROM FLOW DIAGRAM TO INITIAL OPERATION . . . Call on Blaw-Knox for partial or complete engineering-construction service from flow diagrams through erection and initial flow.

One of the many plants and processes available from Blaw-Knox is represented by the typical catalytic reforming units pictured on these pages. Others include distillation, decarbonizing, catalytic cracking, hydrogenation, alkylation, and polymerization processes . . . engineered and erected as single units or as complete refineries. A large staff of Blaw-Knox engineers are available to help you in engineering, revamping and constructing the units and related systems you need. Your inquiries will be handled promptly.

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY

Chemical Plants Division • Pittsburgh 22, Pennsylvania
Chicago 1, Illinois • Birmingham, New York,
Philadelphia, San Francisco, Washington, D. C.

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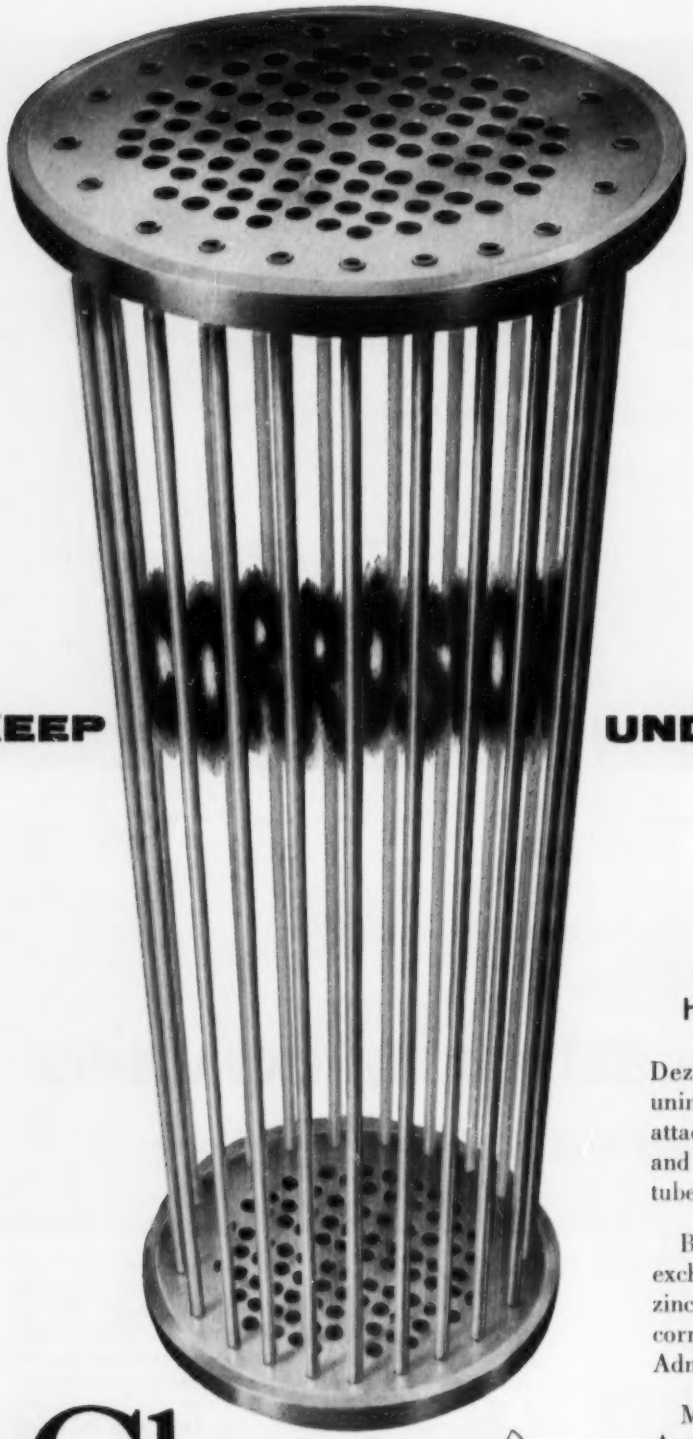

KEEP **UNDER CONTROL...**

with CHASE® Antimonial Admiralty Heat Exchanger Tubes!

Dezincification can make short work of uninhibited condenser tubes! It insidiously attacks the metal surface, dissolving the zinc and leaving porous copper behind until the tube wall is completely penetrated.

But Chase Antimonial Admiralty heat exchanger tube is practically immune to dezincification! What's more, it retains *all* the corrosion resistant properties of ordinary Admiralty.

More than 100 million pounds of Chase Antimonial Admiralty tube have been installed to successfully combat dezincification, since Chase introduced this remarkable alloy in 1935. It may be just the alloy for you, too! Write for complete details.

Chase®
BRASS & COPPER CO.
SUBSIDIARY OF KENNECOTT COPPER CORPORATION • WATERBURY 20, CONNECTICUT

The Nation's Headquarters for Brass, Copper and Stainless Steel

Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

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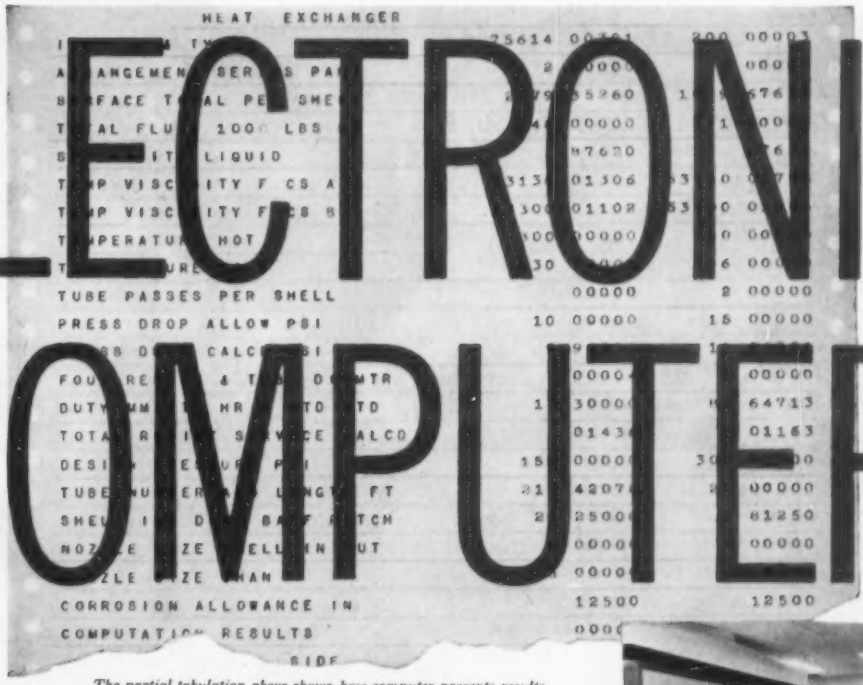
More Precise Design Calculations with M. W. Kellogg's New, Super-Speed ELECTRONIC COMPUTER



The partial tabulation above shows how computer presents results. The computer itself is shown at the right.

The latest addition to The M. W. Kellogg Company's facilities for engineering heat-pressure process equipment is a new, large magnetic drum digital computer. It can execute 500 arithmetical operations per second; conservatively can solve 40 simultaneous equations in 30 minutes; and has a memory capacity of over 4000 ten-digit words.

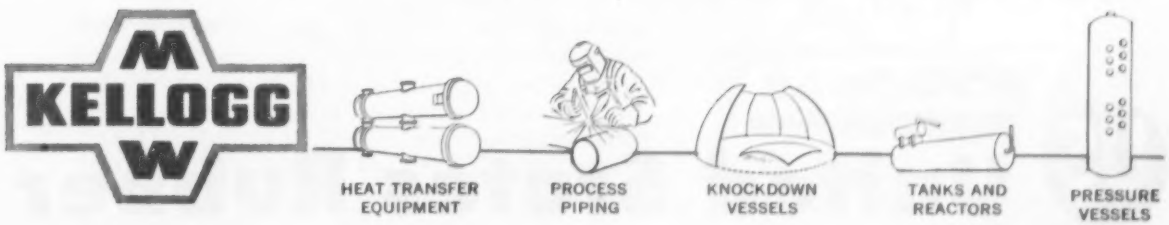
This new computer enables M. W. Kellogg's engineering staff to undertake a far greater number of precise calculations in less time than ever before and, as a result, to determine the optimum designs for customers in minimum time. For example, complete calculations for a liquid to liquid heat exchanger, which formerly took 10 to 15 hours, now can be done in about 15 minutes.

Electronic computation is an important supplement to the productivity of Kellogg's heat transfer engineers and permits them more time for evaluating results and improving designs. We welcome the opportunity to demonstrate what these aspects of Kellogg's "built-in engineer" can contribute to your requirements.

Fabricated Products Division THE M. W. KELLOGG COMPANY 711 Third Avenue, New York 17, N. Y.

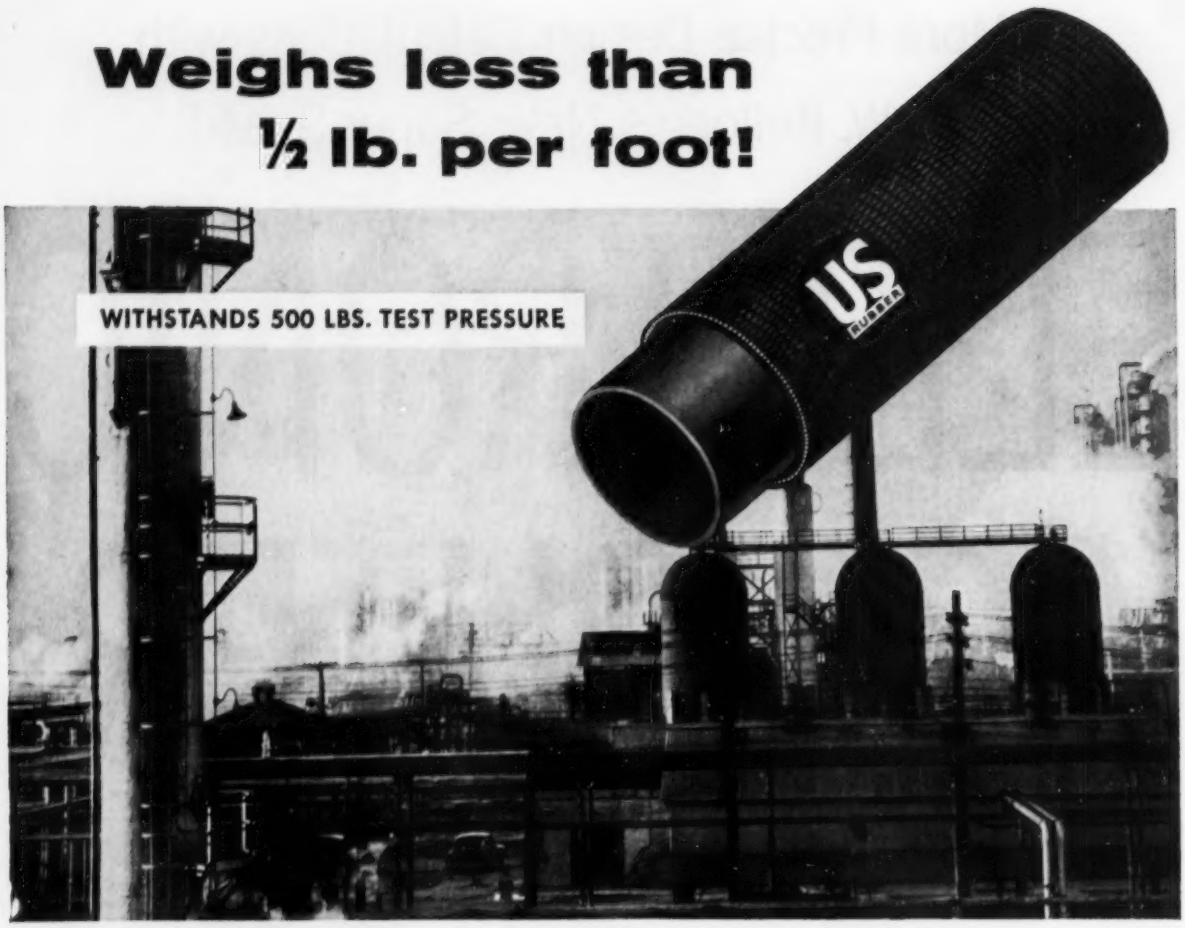
A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Limited, Toronto • Kellogg International Corporation, London • Societe Kellogg, Paris
Kellogg Pan American Corporation, New York • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas



For more data on advertised products, use Readers' Service Cards, last page.

Weighs less than ½ lb. per foot!



The new super-flexible *All-Dacron*

U. S. FLEXLITE® FIRE HOSE!

Its single jacket is all Dacron*—to give the lighter weight, pressure resistance, flexibility, rackability required by today's petro-chemical fire departments.

Although U. S. Flexlite weighs 50% less than conventional hose, it will handle extreme pressures! Its Neoprene tube and Dacron jacket have the required resistance to chemicals, petroleum, mildew, dampness, heat. Coils easily, dries fast. United States Rubber Company also makes the following hose for the petro-chemical field.

(1) "Reliance®" Double Jacket Dacron reinforced (weighs 50 lbs. per 100 ft.) (withstands 400 lbs. test pressure)

(2) "Reliance" Double Jacket Dacron reinforced (weighs 54 lbs. per 100 ft.) (withstands 600 lbs. test pressure)

(3) U. S. Matchless® Carbolized—most rugged hose in the market.

Get in touch with any of our selected distributors or any of the 27 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, New York.

*DuPont's polyester fiber

US RUBBER

Mechanical Goods Division

United States Rubber

Wide Size Range . . . in Any Quantity Builds PETROLEUM Demand for B&W HOLLOW FORGINGS

The Engineers and Fabricators who serve the oil industry have found in B&W Hollow Forgings the answers to problems of size and economy, and as a result they have earned wide acceptance in refinery service. Here are a few of the oil companies that have put B&W Hollow Forgings into refinery service:

Tidewater Oil Co. **Flori Pipe Co., Fabricator**	**Shell Oil Co.** **Flori Pipe Co., Fabricator**
Gulf Oil Corp. **Fluor Corp., Ltd., Fabricator**	**Standard Oil Company of California** **Procon, Incorporated, Contractor**

B&W Hollow Forgings come in a wide range of fractional and standard sizes up to 35⅝ inches O.D., and a choice of analyses, to precisely fit your specific needs. They can be produced in any desired quantity.

Send for Bulletin S-16B. This gives you the complete details of B&W Hollow Forgings. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

BABCOCK & WILCOX

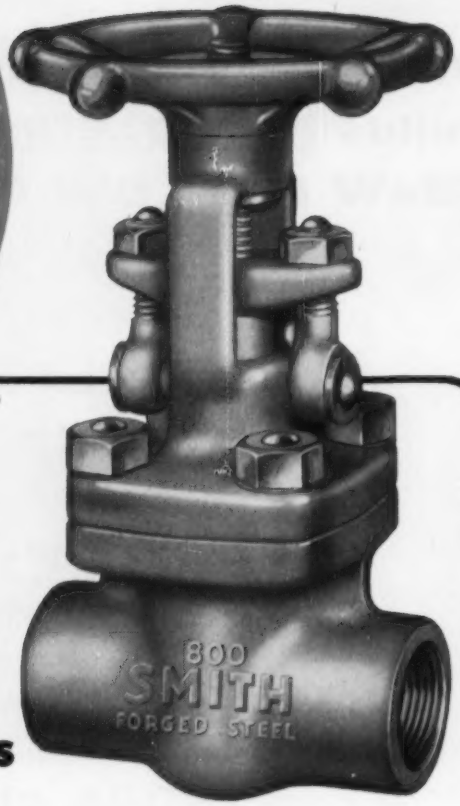
BOILER DIVISION

S-462

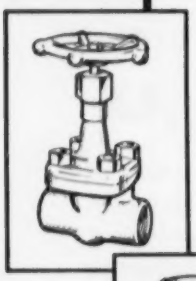
For more data on advertised products, use Readers' Service Cards, last page.

Smith FORGED STEEL Valves

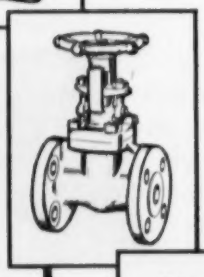
SMITH "FIGURE 800" O S & Y GATE VALVE



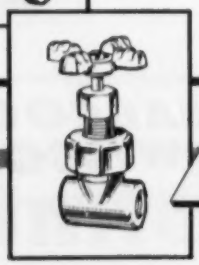
Especially Designed for the REFINERY, CHEMICAL, POWER and PROCESS INDUSTRIES



INSIDE SCREW VALVES



FLANGED END GATE VALVES



NEEDLE GLOBE VALVES

SMITH VALVES were designed and engineered only after years of exhaustive study and research in the engineering departments of the Refinery, Chemical, Power and Process industries. The combined ideas and special features suggested by the Design Engineers, Material and Specification Engineers, Process Piping and Maintenance Engineers of these major industries have been built into SMITH VALVES.

Enthusiastic reports from these industries are a clear indication that SMITH VALVES have successfully passed the test of actual operation and have more than justified the many years of consultation and research which preceded their introduction to the market.

Because they are precision-built to the most exacting standards of accuracy, using only the highest quality materials and the utmost in manufacturing skills, SMITH VALVES are guaranteed stronger, safer and easier to operate at lowest possible maintenance cost.

Specify SMITH VALVES for longer trouble-free life in service

NEW ENGLAND VALVE Corporation

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

For more data on advertised products, use Readers' Service Cards, last page.

"Wrinkle-proof suit coming up!"

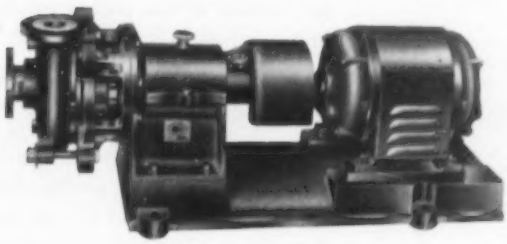
Today, through the magic of chemistry, new "miracle" fabrics with built-in resistance to wrinkles, moths, mold and mildew, are a reality. In modern chemical plants where the synthetic fibers for these new fabrics are made, highly corrosive process solutions are handled efficiently and economically by . . .

WILFLEY

ACID PUMPS

Wherever installed, Wilfley Acid Pumps reduce costs and increase production . . . deliver trouble-free performance 24 hours a day. Available with pumping parts of the machinable alloys as well as plastic to meet all requirements. Write or wire for complete details.

Individual Engineering on Every Application



WILFLEY ACID PUMPS
"COMPANIONS IN ECONOMICAL OPERATION"
WILFLEY SAND PUMPS

A. R. WILFLEY AND SONS, INC.

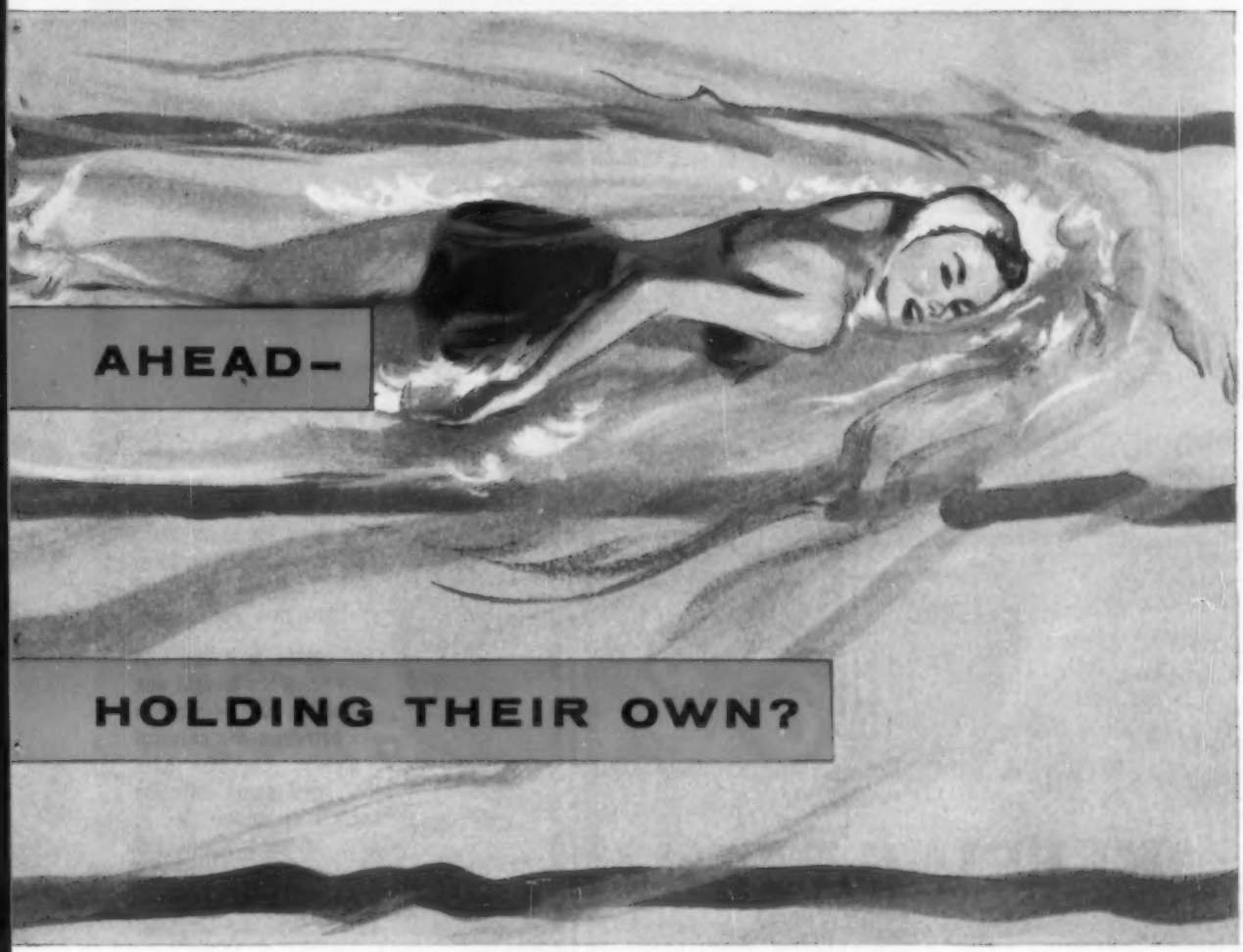
DENVER, COLORADO, U.S.A.
NEW YORK OFFICE: 1775 BROADWAY, NEW YORK CITY

Today's constantly increasing demand for higher octane gasolines poses a challenge to every refiner. If you do not meet this demand efficiently and economically you may very well forfeit your competitive position in the race for the motorist's dollar.

So, look to your pool octanes. You need to make sure that your refining processes provide maximum quality to *every* gallon of gasoline produced. And this just can't be done with one high octane stream. It requires an improvement of the poorer quality blending components that lower pool gasoline octanes.

This is why UOP has devoted much of its research toward the up-grading of the poorest quality components that go to make up the finished gasoline pool.

An important result of this work is Universal's latest refining process—PENEX. This new process offers an efficient and practical method of up-grading pentane and hexane fractions, the previously neglected components that can so adversely affect the octane ratings of your pool gasoline.



In the race for higher octanes, you cannot afford to forget that the goal is to improve the general quality of your pool gasolines. PENEX offers a means of accomplishing this practically and economically. It should be given immediate consideration in your planning.

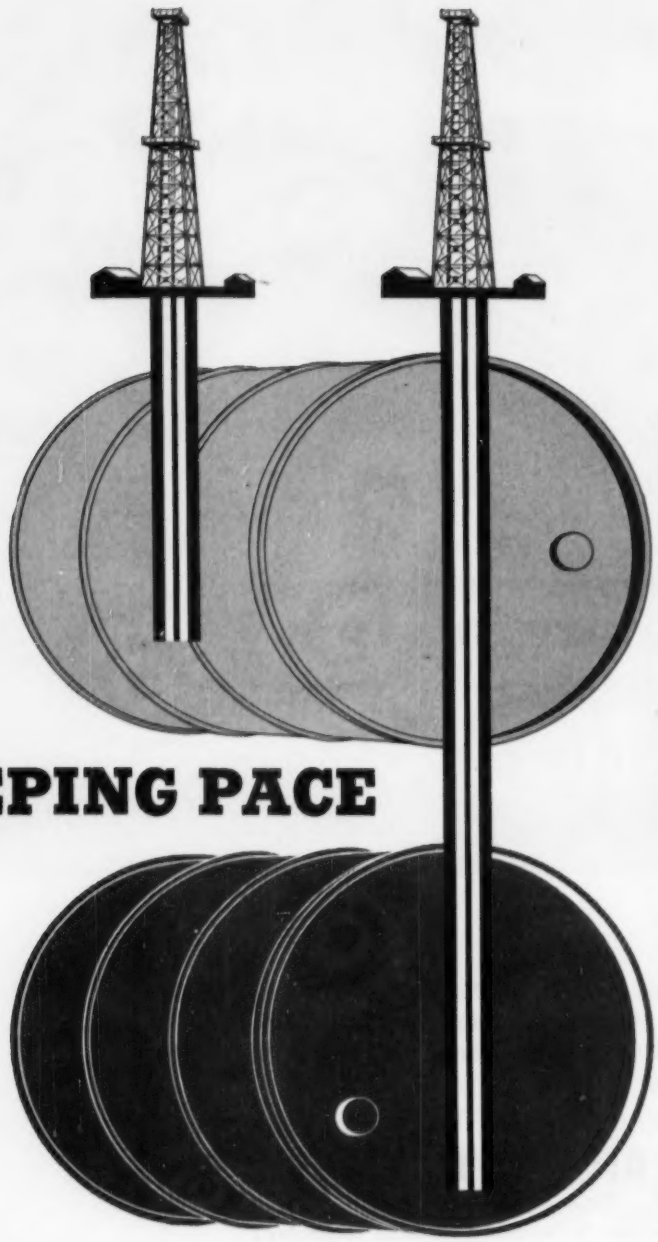
UOP® UNIVERSAL OIL PRODUCTS COMPANY
30 Algonquin Road, Des Plaines, Illinois, U. S. A.
Forty Years Of Leadership In Petroleum Refining Technology

PENEX

TRADEMARK

A new isomerization process for up-grading pentane and hexane fractions

For more data on advertised products, use Readers' Service Cards, last page.



KEEPING PACE

Drills were chewing their way down for about 2000 feet in the search for oil in 1916. Today's drilling depth is more than double that.

The change in drilling that forty years has brought well symbolizes many advances in the petroleum and chemical industries. Engineers have dug more deeply into the secrets of nature, too . . . have designed plants and processes to wrest new products and services from petroleum, ores and elements.

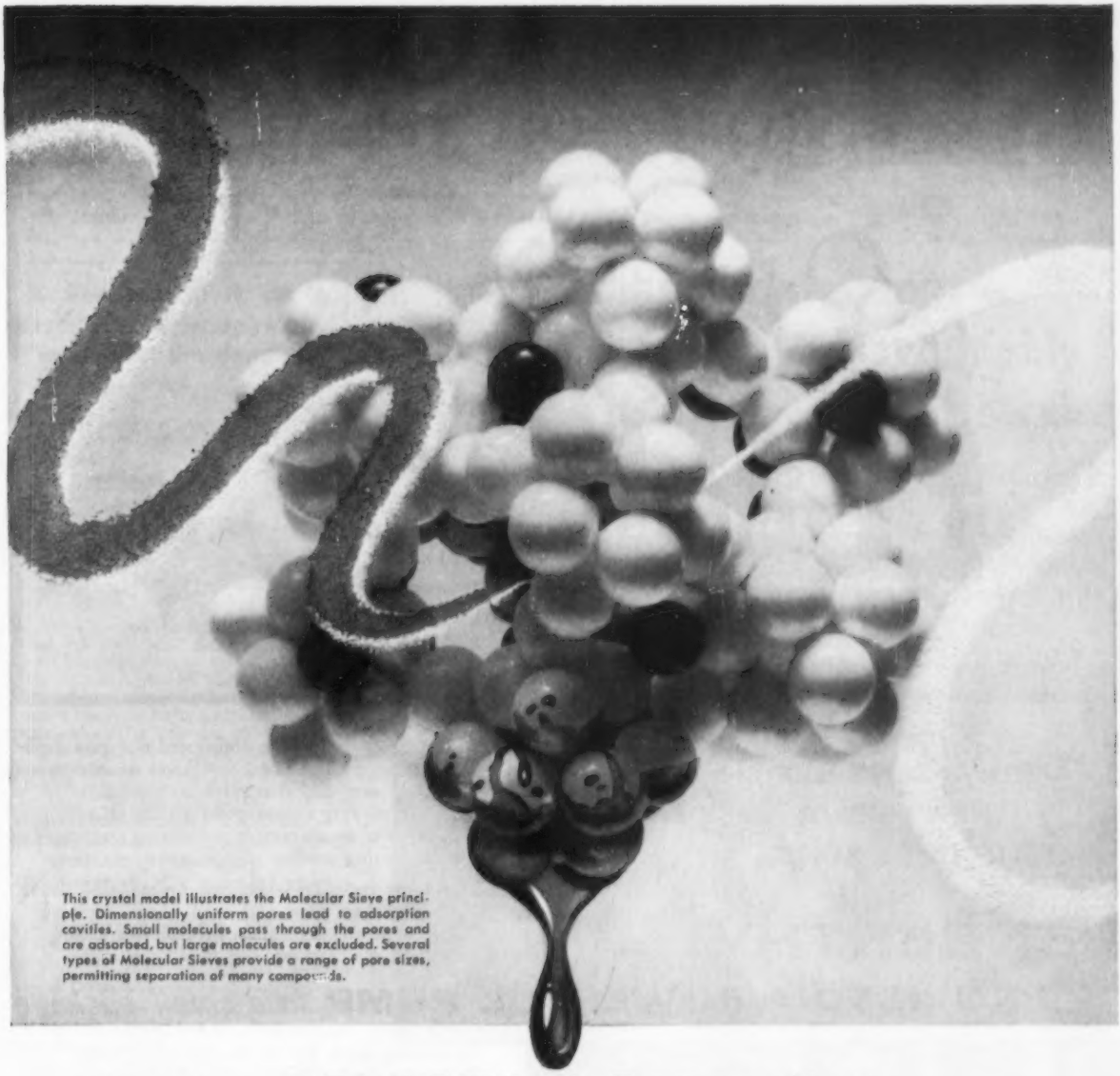
We mentioned 1916 because that is the year Sun Ship was founded. It has long served the swift-growing needs of petroleum and chemical industries. Year by year, the engineering skill and facilities of the great Sun Ship plant have proven their ability to meet the demands for plant and equipment keyed to the swift pace of progress in these and other important fields. Sun Ship keeps pace with progress.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.



This crystal model illustrates the Molecular Sieve principle. Dimensionally uniform pores lead to adsorption cavities. Small molecules pass through the pores and are adsorbed, but large molecules are excluded. Several types of Molecular Sieves provide a range of pore sizes, permitting separation of many compounds.

Now...SELECTIVE Separation with MOLECULAR SIEVES

LINDE Molecular Sieves, a new *class* of adsorbents, offer unique performance in product purification and recovery. These crystalline zeolites provide selective separation of gas and liquid mixtures in *three* ways... difference in molecule size... or polarity... or carbon bond saturation.

Selective removal of contaminants, even in trace amounts, is possible at temperatures up to 300° F. Selective recovery of valuable stock is often accomplished without regard to relative boiling points. Co-adsorption eliminates extra processing steps by removing several impurities simultaneously. High capacity is realized through a wide range of operating conditions.

Typical uses for Molecular Sieves are the separation of n-paraffins from iso-paraffins and cyclics . . . extraction of olefins from refinery streams and top gases... removal of catalyst poisons from olefins... sweetening of natural gas and reformed hydrogen... purification of annealing gases.

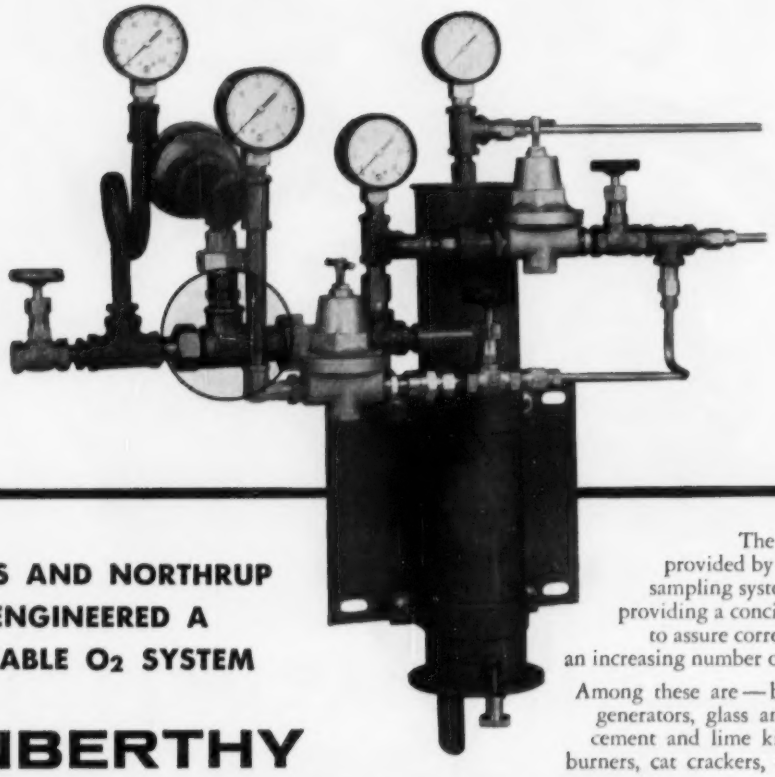
For a descriptive booklet, "Molecular Sieves for Selective Adsorption," write Dept. PR-11, Linde Air Products Company, A Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y.

Linde TRADE MARK MOLECULAR SIEVES

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation

For more data on advertised products, use Readers' Service Cards, last page.

TO STOP DOLLARS *from* GOING UP THE FLUE...



LEEDS AND NORTHRUP ENGINEERED A RELIABLE O_2 SYSTEM

The high-speed flue gas sample provided by L & N's new steam-operated sampling system is instrumental in providing a concise and reliable O_2 picture to assure correct combustion conditions in an increasing number of industrial applications.

Among these are — boilers, atmosphere generators, glass and open hearth furnaces, cement and lime kilns, hydroformers, SO_2 burners, cat crackers, and fluid coke units.

PENBERTHY PROVIDED A POWERFUL PUMP *in a small package*

In moving stack gas to the analyzer . . . the Penberthy Ejector offers practical advantages over mechanical pumps. Smaller, more compact and less costly, it is assembled as an integral part of L & N's equipment. It is not subject to mechanical failure (no moving parts) and has high corrosion resistance.

LOCAL JOBBER SUPPLIED INITIAL UNITS

Like L & N, you, too, will find that leading supply companies carry a complete line of standard Penberthy Ejectors suitable for most pumping applications. For special jobs or detailed technical information, write direct.

PENBERTHY MANUFACTURING CO.

Division of Buffalo-Eclipse Corporation

1242 Holden Avenue Detroit 2, Michigan

***There's Certain Satisfaction in* PRODUCTS BY PENBERTHY**

- GAGES
- EJECTORS
- EDUCTORS
- EXHAUSTERS
- SYPHONS
- ELECTRIC SUMP PUMPS
- CYCLING JET PUMPS
- INJECTORS

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

November ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

Du Pont uses sports car to study fuel-injection related to product development

Although sports cars are designed for road racing or as a highway hobby, the Du Pont Petroleum Laboratory is now using one for an entirely different purpose.

With an eye to future automotive fuel requirements, the laboratory is now fitting out a new Mercedes-Benz, 300 SL, with special instrumentation. The objective is to investigate the additive needs of fuels for fuel-injection engines and to test promising candidates under actual road conditions. The Mercedes-Benz was picked for this work because it is the only car with a fuel-injection engine that is commercially available in this country.

Mercaptide problems solved with DMD

If you are not now using Du Pont Metal Deactivator in your heating and diesel fuels, we believe you will be interested in the success of other refiners who have used it.

Several years ago, for example, a major oil company was having copper mercaptide problems. They encountered the trouble in both straight-run diesel fuel and No. 2 fuel oil composed of 95% straight-run and 5% Houdry cat-cracked.

To solve the problem, 2 pounds of DMD per 1,000 barrels were added to both fuels. This proved highly successful for several seasons. Then the use of DMD was discontinued. The trouble recurred. So DMD was again added, and this company's mercaptide problem was again under control.

Another major company encountered gel-clogging complaints in the Spring of 1955. The trouble involved a No. 2 fuel oil composed of fluid cat-cracked and straight-run. The cracked component varied in composition from 75% to 90%.

During the next heating season, the company added 2 pounds of DMD (in combination with Du Pont Fuel Oil Additive No. 2) per 1,000 barrels. There were no complaints of mercaptide formation reported the following season.

These are only two of the many success stories reported by refiners using DMD to combat mercaptide problems and complaints. And many refiners have found that since the cost of adding effective amounts of DMD is so low, it pays to use it as an "insurance" against copper contamination in a wide variety of products.

Greases containing Du Pont Estersil GT prove highly successful in many types of service

It was about two years ago that Du Pont estersil grease thickener was first introduced.

Since then, millions of pounds of grease made with this unique thickening agent have been used in a wide variety of industrial and automotive applications. And the success obtained with these greases has been truly outstanding.

Photo courtesy Joy Mfg. Co.

CONTINUOUS MINER—completely lubricated with estersil grease

One coal mining company, for example, reports that they eliminated the need for using three different mining equipment lubricants by standardizing on semi-fluid estersil-based grease in their continuous miners, loading machines and shuttle cars.

In the gear cases of the continuous miners, this company, before using an estersil grease, had a lubricant consumption of two to three *gallons* per shift. When they changed to an estersil grease, they found that the average consumption immediately dropped 75% to two to three *quarts* per shift. On loaders they actually stopped keeping records because the consumption was so small.

Longer gear life

When rebuilding machines, this same company had almost always replaced bearings and gears. But since switching to the estersil grease, they found that the gears could be used over and over again without significant wear. This was probably due — at least partially—to the fact that the estersil grease effectively sealed out moisture, dirt, coal dust and other abrasive foreign matter.

Maintenance costs down

Another user in the coal industry re-

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

CONTINUED *Estersil GT*

ports that the use of an estersil-based grease has caused his maintenance costs on a group of cutting machines to drop from .185 cents per ton to less than .09 cents per ton—a 50% saving.

Many users report that equipment runs much cooler and quieter with estersil-based greases.

In addition to heavy-duty industrial applications, estersil greases have been used in several automotive applications. In passenger cars, test engineers

THIS DEMONSTRATION dramatizes the unusual water resistance of estersil greases. They can be immersed in boiling water for long periods without breakdown.

report, these greases greatly prolong the smoother, easy-riding effect of a fresh lube job.

In heavy-duty earth-moving equipment, estersil greases often provide significant savings in downtime and maintenance costs. In some instances, crane and shovel operators reported an almost immediate cessation of leakage from hoist drum bearings on to the brake bands after switching to estersil grease.

Exceptional water resistance

Du Pont Estersil GT is an entirely *new type* of grease thickener. It is a pelletized form of finely divided amorphous silica. One of its unique features is that each minute particle is enveloped in a chemical "raincoat" which gives estersil-based greases positive, built-in water resistance and eliminates the danger of washout.

Continued middle next column

ASSISTANT TO THE SALES MANAGER—ADDITIVES

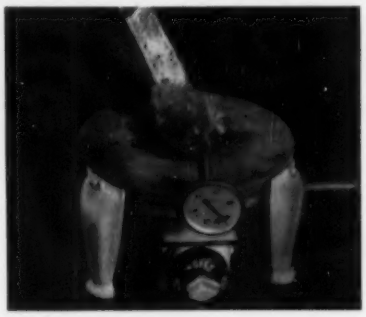
RICHARD O. BRAENDLE joined the Du Pont Company in 1944 after receiving his B.S. degree in Chemical Engineering at Massachusetts Institute of Technology.

He was first assigned to the Grasselli Chemicals Department's Experimental Laboratory in Cleveland. There he did development research on inorganic chemicals, mainly estersils. In 1950, he was transferred to the Du Pont Experimental Station in Wilmington where he worked on the application of estersils as grease thickeners.

He joined the Technical Section of the Petroleum Chemicals Division in 1952, continuing his product development work on estersil GT. During 1955 he did market research analysis for a number of petroleum additives which led to his current assignment as assistant to the sales manager for additives.

During World War II, Mr. Braendle served in the U. S. Army as a researcher and supervisor of a manufacturing operation on the Manhattan Project. He is a member of the American Chemical Society and the American Society of Lubrication Engineers.

RICHARD O. BRAENDLE



ESTERSIL GT greases stand up unusually well even under the combined action of intense heat and vigorous mechanical working.

Excellent heat and shear stability

Estersil greases are non-melting, and extremely wide temperature ranges produce little change in their consistency.

Even under prolonged high-shear, high-temperature operating conditions, greases made with Du Pont Estersil GT show outstanding resistance to mechanical breakdown.

Handling qualities

Greases thickened with estersil can be easily handled in any application—because their unusually high thermal and mechanical stability permits use of a much softer grease.

Estersil greases can be easily made, too. A milling operation is all that is required because of the completely synthetic, preformed thickening structure of estersil GT.

A Du Pont Petroleum Chemicals Division representative will be glad to give you more detailed information on estersil GT. Contact any of our sales offices listed below.

DU PONT

Better Things for Better Living
. . . *through Chemistry*

Petroleum Chemicals

E. I. DU PONT DE NEMOURS & COMPANY (INC.) *Petroleum Chemicals Division* • *Wilmington 98, Delaware*

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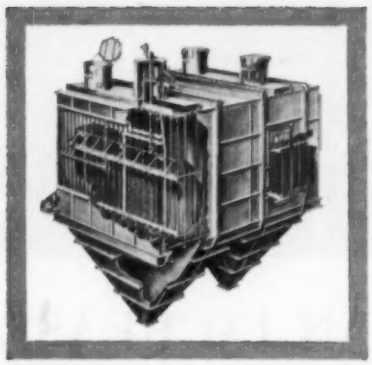
A-2826

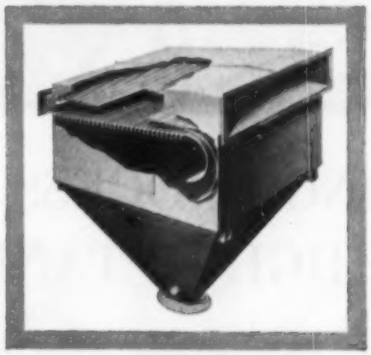
Printed in U. S. A.

How Buell's exclusive Shave-off pays off in extra dust collection efficiency



Buell SF Electric Precipitator also delivers extra dust collection efficiency, due to unique Spiralectrodes and Continuous Cycle Rapping.

Proper proportioning, side entry of dust-laden gases, add even more extra efficiency and long, maintenance-free life to Buell Cyclones. Large diameter design eliminates bridging and clogging, keeps efficiency high under varying loads.

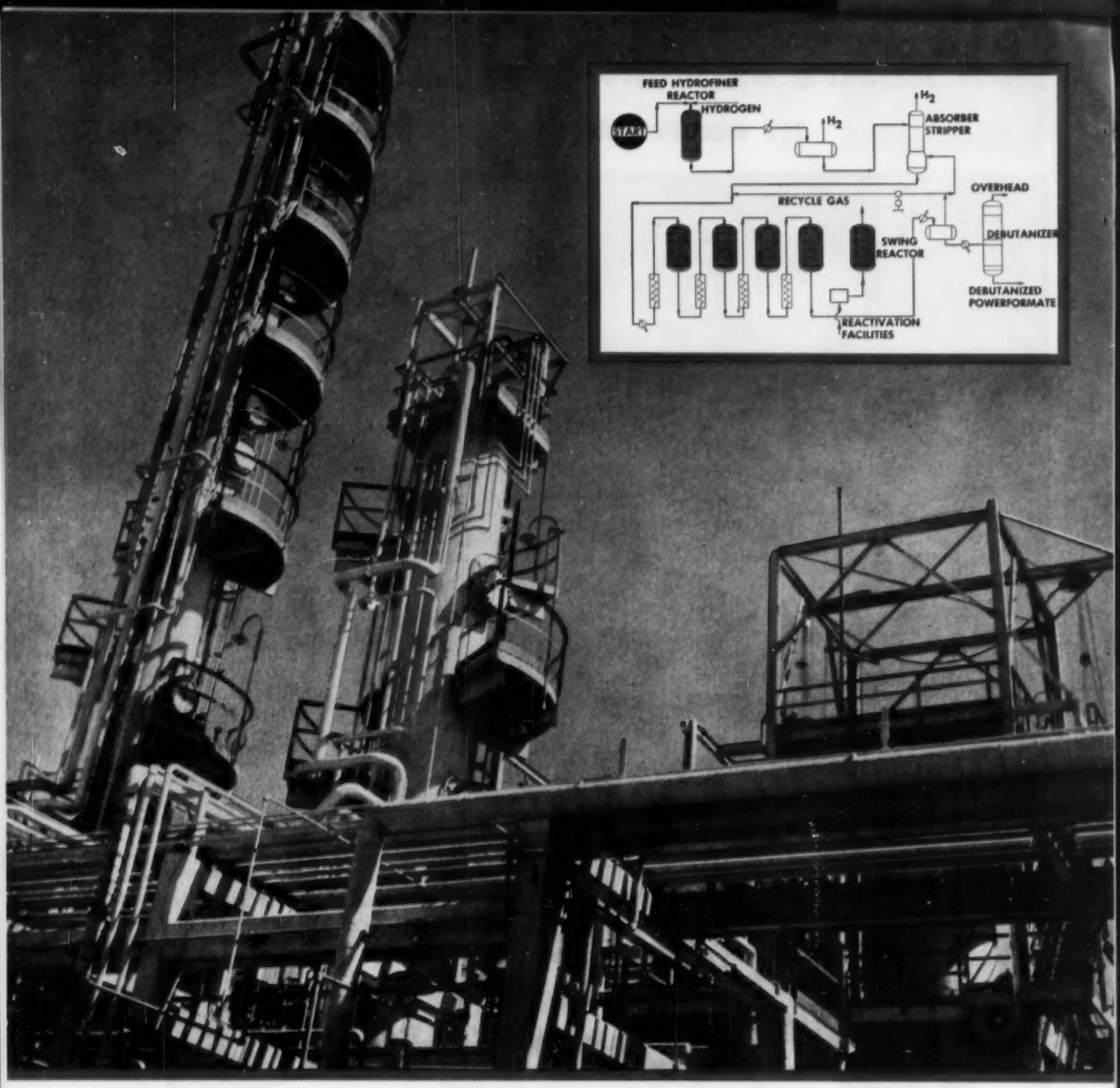


Buell Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or mechanical draft installations.

For more specific data about Buell's *extra efficiency*, write Dept. 21-K, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell

MECHANICAL ELECTRICAL *Experts at delivering Extra Efficiency in* **DUST COLLECTION SYSTEMS**



POWERFORMING PROCESS CAN INCREASE YOUR HIGH OCTANE YIELD

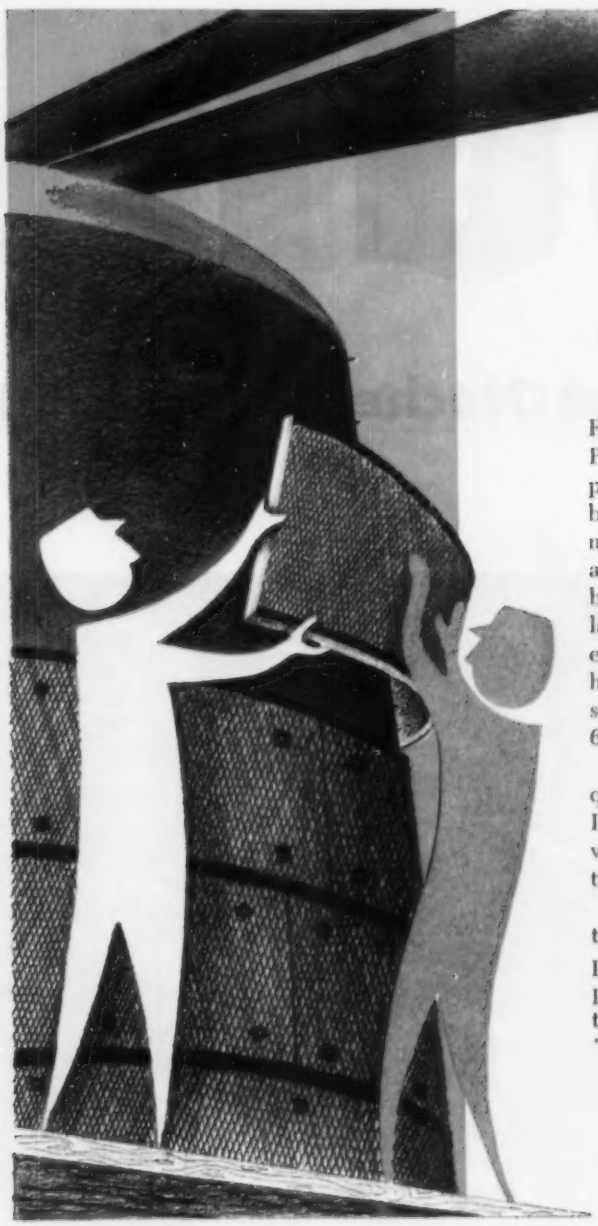
Esso Research and Engineering Company offers you *Powerforming*, the most versatile platinum reforming process ever developed. *Powerforming* is another achievement of the Esso Research program – 37 years of new process developments which have been made available to refiners around the world.

Heart of the *Powerforming* process is a new, more active platinum catalyst. High activity over a long life is assured by significant new regenerative techniques. With this new process, good yields of 100 octane clear Powerformate can even be obtained from paraffinic stocks. Three *Powerforming* installations are on stream; eighteen are in the planning or construction stage. Licensees enjoy benefits of continuing *Powerforming* research. We would welcome your inquiry on the part *Powerforming* can play in *your* modernization plans.

ESSO RESEARCH AND ENGINEERING COMPANY

15 West 51st St., New York 19, N. Y.

Your key to progress... an Esso Research process



Flexible blanket speeds insulation of large, heated equipment

Flexible, easily handled Armstrong Armatemp* Blanket Insulation is especially fast and easy to apply to the curved and irregular surfaces of tanks, breechings, heat exchangers, and other large equipment operating up to 1200° F. Armatemp Blankets are made of felted layers of mineral wool, faced on both sides with various combinations of wire mesh, lath, and fly screen. The insulation's smooth, firm edges can be butted tightly together for efficient, heat-tight joints. Armatemp comes in standard sizes of 2′ x 4′ and 2′ x 8′ and in thicknesses of 1″ to 6″. Special sizes are also available on order.

Armatemp Blanket Insulation is one of the many quality products in the complete line of Armstrong Industrial Insulations. Armstrong also offers a well organized contracting service, geared to install these materials efficiently and economically.

For additional information on Armstrong Armatemp Blanket Insulation or any other Armstrong product that may help to solve your insulation problems, send today for free booklets. Check the ones you want on the coupon below.

*TRADE-MARK

Armstrong

INDUSTRIAL INSULATIONS

☐ Armstrong Armatemp Block and Blankets

☐ Armstrong Armaglas† Insulations for Piping, Tanks, and Vessels

☐ Armstrong LT Cork Covering for All Cold Lines

☐ Armstrong Insulcolor®, Weatherproof Coating in Eight Colors

† ® Armstrong Cork Co., Manufactured by Owens-Corning Fiberglas Corp.

Armstrong Cork Company
2011 Room Ave.
Lancaster, Penna.

Please send me the free booklets checked. ☐

Please have an Armstrong representative call. ☐

Name .....

Position .....

Company .....

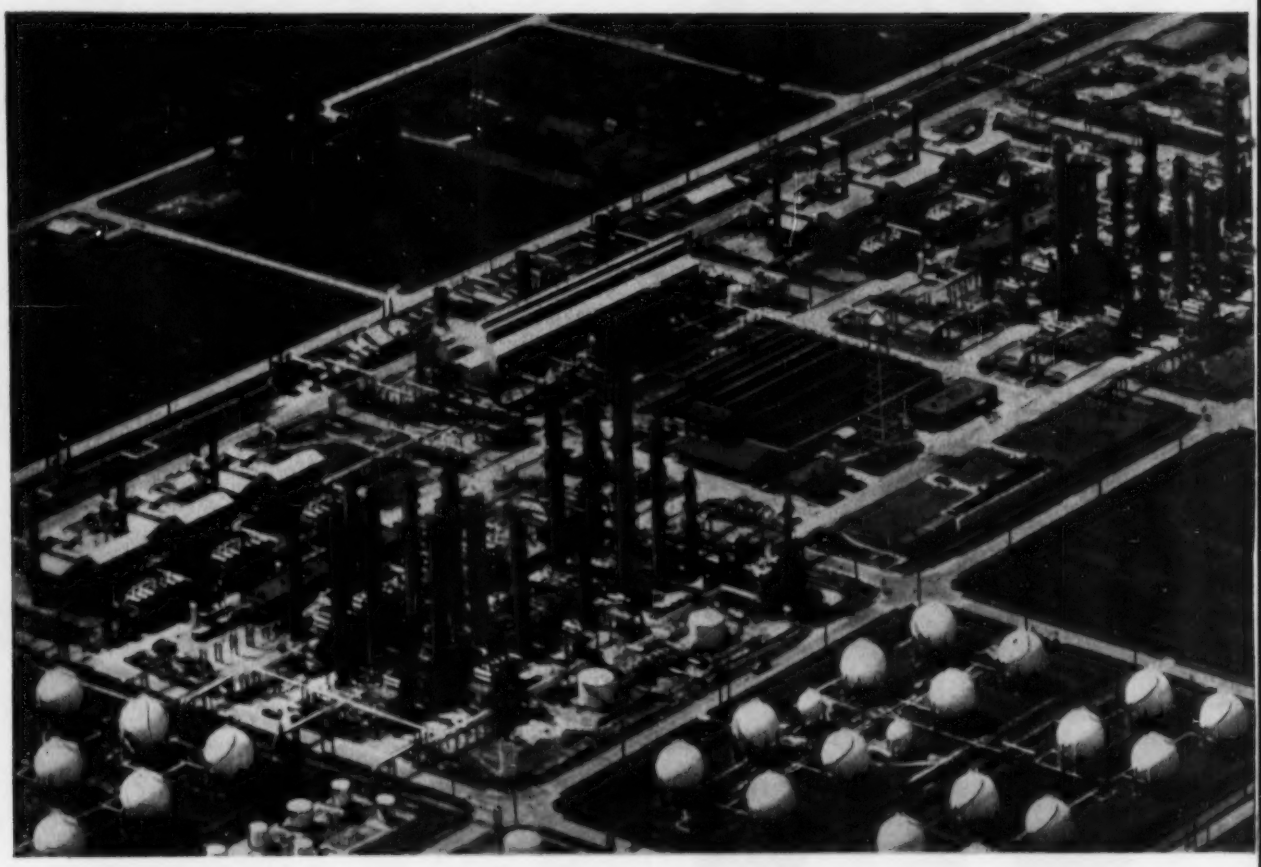
Address .....

City ..... Zone .... State .....

For more data on advertised products, use Readers' Service Cards, last page.

buta

Port Neches expansion,



Present facilities of the world's largest Butadiene plant – the Port Neches plant of Neches Butane Products Company – will be augmented by Foster Wheeler to effect a 50% increase in total capacity.

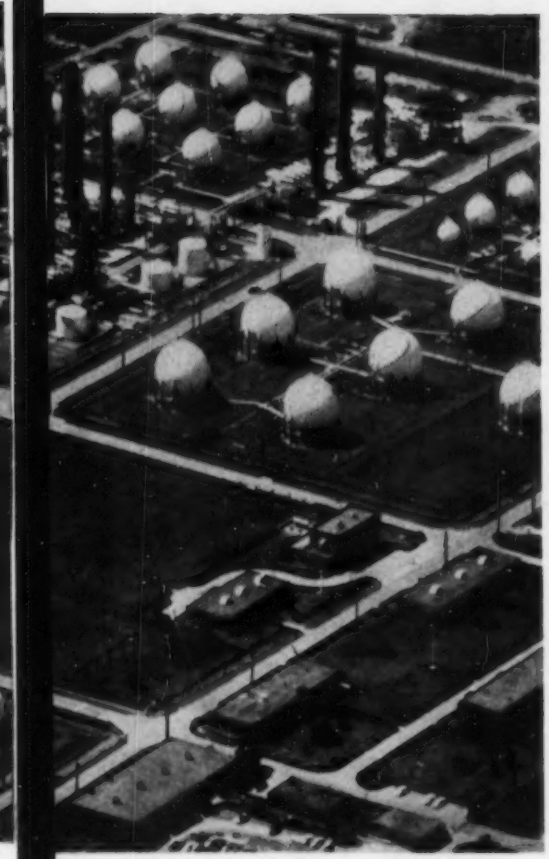
FOSTER

NEW YORK • LONDON

diene

200,000 to 300,000 tons/year

by Foster Wheeler



FOSTER WHEELER CORPORATION will provide process and mechanical design, engineering and construction for the expansion program at the Port Neches Butadiene plant of the Neches Butane Products Company. The plant, recently purchased from the government, is jointly owned by the Texas-U.S. Chemical Company and Goodrich-Gulf Chemicals Inc.

The present capacity of this plant, the largest in the world for the production of Butadiene, will be increased from 200,000 tons/year to 300,000 tons/year.

In addition to new process units, new steam generation, cooling water utilities and inter-plant facilities will also be provided by Foster Wheeler.

With engineering offices in New York, London, Paris and St. Catharines, Ontario, and complete fabrication facilities at Mountaintop, Pa., Dansville, N. Y., Carteret, N. J., St. Catharines, Ontario and Egham, Surrey, England, Foster Wheeler offers a world-wide service in the design, engineering, fabrication and construction of petroleum, petrochemical or chemical process plants or processing units.

WHEELER

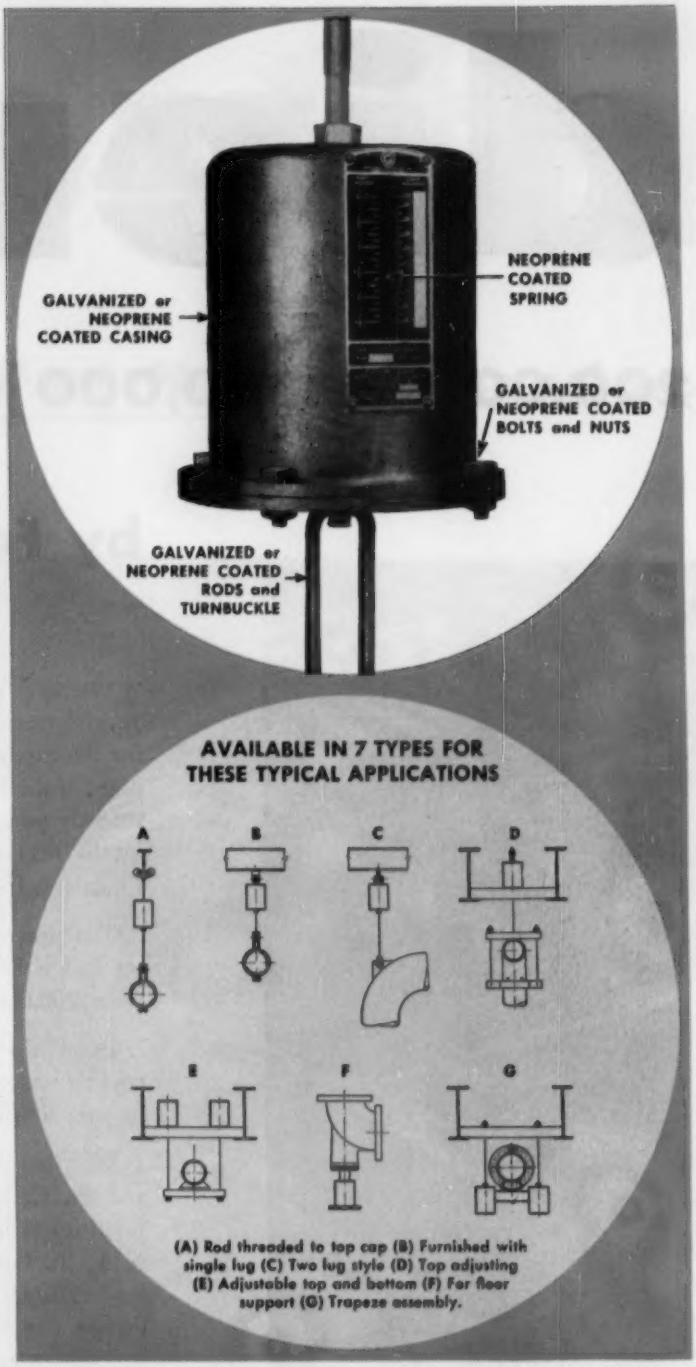
PARIS • ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

NEW

weather-resistant, corrosion-resistant

GRINNELL VARIABLE SPRING HANGERS...


GALVANIZED or NEOPRENE COATED CASING
NEOPRENE COATED SPRING
GALVANIZED or NEOPRENE COATED BOLTS and NUTS
GALVANIZED or NEOPRENE COATED RODS and TURNBUCKLE
AVAILABLE IN 7 TYPES FOR THESE TYPICAL APPLICATIONS
A
B
C
D
E
F
G
(A) Rod threaded to top cap (B) Furnished with single lug (C) Two lug style (D) Top adjusting (E) Adjustable top and bottom (F) For floor support (G) Trapeze assembly.

Another Grinnell First!

Grinnell pre-engineered spring hangers are now offered in two new lines to meet the need for spring hangers in installations subject to highly corrosive industrial conditions and to severe weather exposure.

These hangers are the result of extensive experimentation with various coatings for Grinnell's standard pre-engineered spring hangers. In addition to providing flexibility in pipe suspension, they provide versatility of application through their corrosion-resistant characteristics. They are . . .

1. Neoprene coated—for highly corrosive conditions such as those found in chemical plants and refineries. *All* parts of the hanger are neoprene coated to protect the base metal from a wide range of corrosives. The flex life of the spring is unaffected by the neoprene . . . the coating resists cracking or flaking over a wide temperature range.

2. Galvanized—for outdoor installations where weather conditions are severe. All parts of the hanger are galvanized except the spring, which is neoprene coated to avoid alteration of temper, hydrogen embrittlement and decreased flex-life of the spring—usual hazards to springs from the galvanizing process.

Along with the obvious advantages of such corrosion and weather-resistant characteristics, consider these features...

- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity—in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- 18 sizes available from stock for load ranges from 53 lbs. to 12,000 lbs.
- Available in 3 spring lengths for travel ranges of 1¼, 2½, and 5 inches.
- Installation is simplified by integral load scale and travel indicators.

*Precompression is a patented feature.

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

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to meet exacting lubrication standards, specify

ENJAY PARATONE®

viscosity-index improver

For peak efficiency in compounding oils for both hot and cold weather conditions, blenders and refiners are turning to Enjay Paratone. This famous additive produces a year-round lubricant combining cold-weather, quick-starting properties with low consumption characteristics.

Through constant research and technical experience with equipment manufacturers and users, Enjay has developed a *complete line* of high-quality additives (Paramins®) for blending with every type of base stock. To obtain this experience for *your* processing operations, write, wire or phone the Enjay Company today.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st STREET, NEW YORK 19, N. Y. • Other offices: Akron, Boston, Chicago, Tulsa

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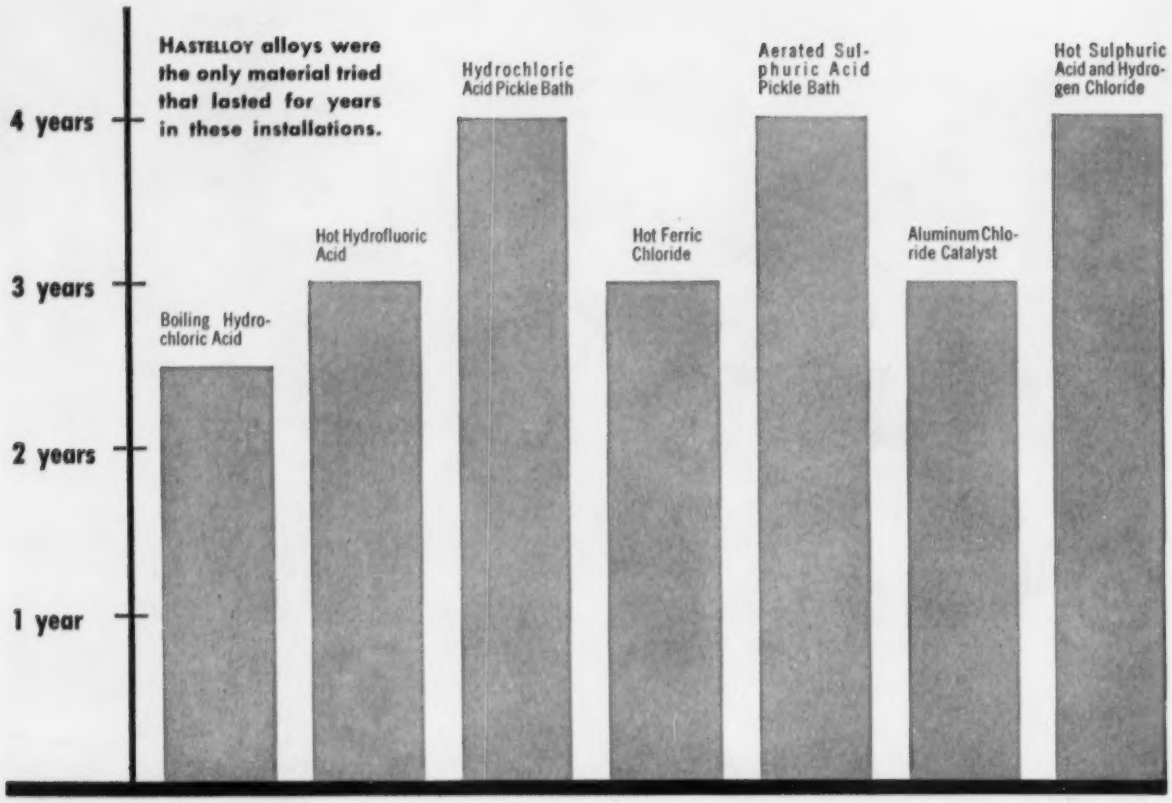
HASTELLOY alloys were the only material tried that lasted for years in these installations.
4 years
3 years
2 years
1 year
Boiling Hydrochloric Acid
Hot Hydrofluoric Acid
Hydrochloric Acid Pickle Bath
Hot Ferric Chloride
Aerated Sulphuric Acid Pickle Bath
Aluminum Chloride Catalyst
Hot Sulphuric Acid and Hydrogen Chloride

HASTELLOY Alloys *last for years under severe corrosive conditions*

These graphs were drawn from data on actual installations of HASTELLOY alloys in severe corrosive media. No other material tried lasted more than six months in most of these installations, some considerably less than this. HASTELLOY alloys lasted for years.

Use of HASTELLOY alloys saved time, money, and production time in all the installations. The graphs do not tell the entire story by any means. Some of the parts made of HASTELLOY alloys were still going strong when the data were obtained. In some, corrosion was complicated by abrasion, impact, and the presence of contaminants.

Samples for testing HASTELLOY alloys under actual operating conditions are available without obligation. Just let us know what corrosive conditions are involved. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company Office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation.

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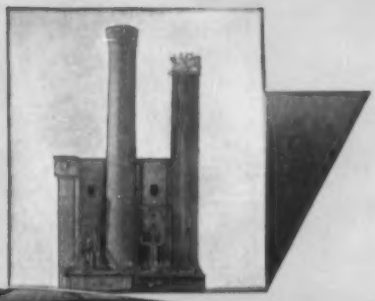
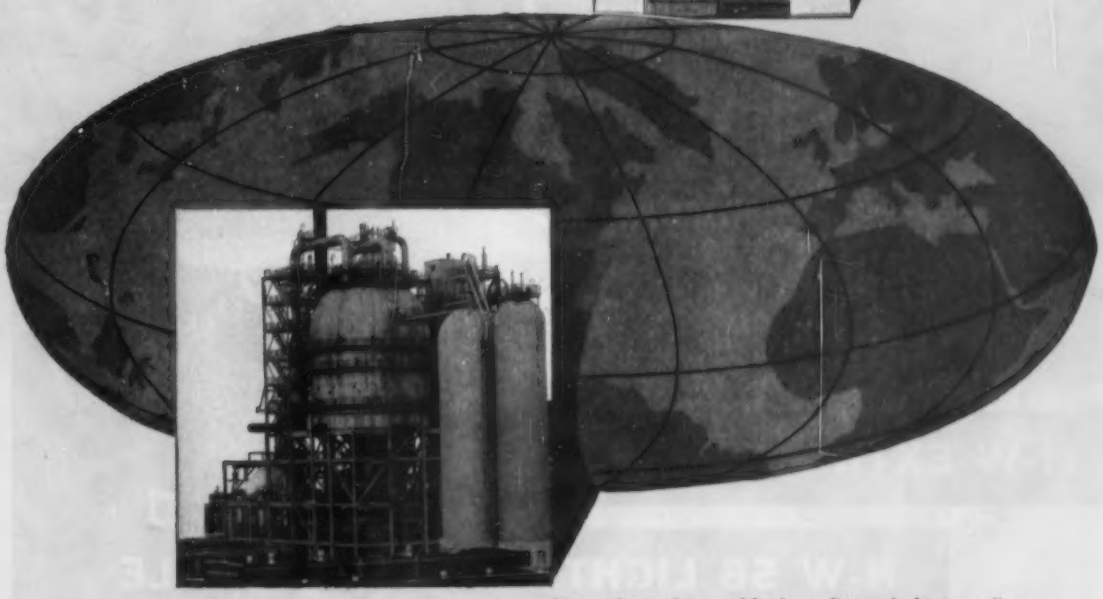
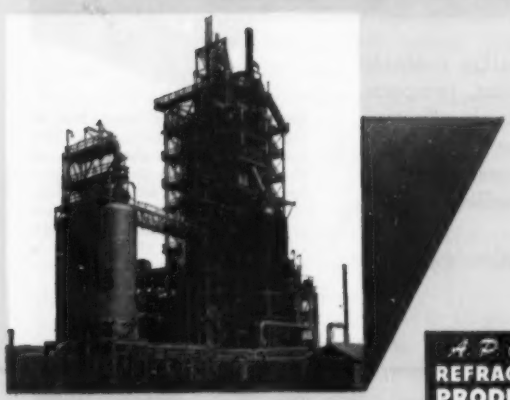
ALL OVER THE WORLD

A. P. GREEN

Serves the Refinery Industry with a Complete Line of High Quality Refractory Products







Throughout the world, the refinery industry relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, etc.

A world-wide network of A. P. Green distributors is always ready to help you select the right refractories to do the best possible job . . . at the lowest cost. Regardless of location, A. P. Green refractories reach you quickly, safely, exactly as ordered.

A. P. Green
REFRACTORY
PRODUCTS

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS: Mexico, Mo. • Woodbridge, N. J. • Sulphur Springs, Texas
In Canada: **A. P. GREEN FIRE BRICK COMPANY, LTD.**
Toronto 15, Ontario

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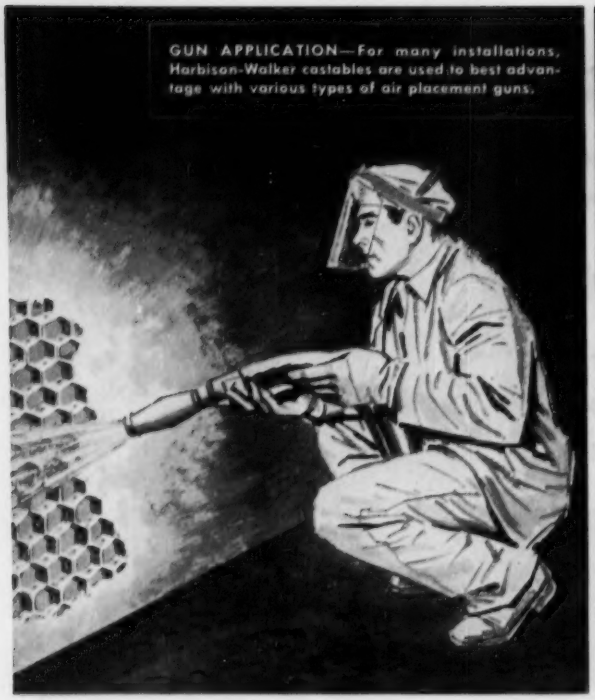
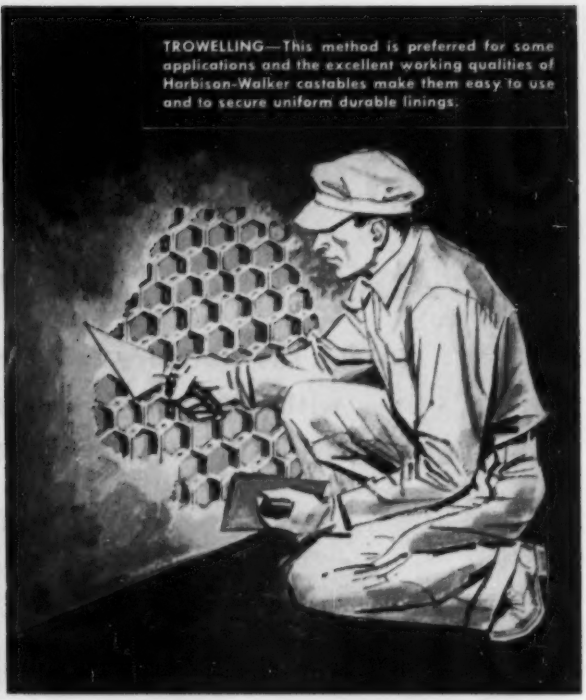


GUN APPLICATION—For many installations, Harbison-Walker castables are used to best advantage with various types of air placement guns.



TROWELLING—This method is preferred for some applications and the excellent working qualities of Harbison-Walker castables make them easy to use and to secure uniform durable linings.

For refractory linings that last longer...
specify HARBISON-WALKER

H-W EXTRA STRENGTH CASTABLE

H-W 56 LIGHTWEIGHT CASTABLE

Used together as illustrated, these two Harbison-Walker castable refractories form a lining that withstands the erosion, temperatures and pressures of refinery units, and provides highly effective insulation that reduces heat losses. Both products are particularly suited for service in catalytic cracking regenerators, reactors, catalyst feed lines and other units. They can be trowelled, poured like concrete, tamped or applied with air guns.

Write for complete information about these refinery-proved Harbison-Walker castable refractories.

Cross-sectional view shows H-W 56 Lightweight (insulating) Castable next to the regenerator shell, with H-W Extra Strength Castable superimposed for the working lining, where its high strength, excellent erosion resistance and low coefficient of expansion all contribute to long service life.

Harbison-Walker Refractories Company
AND SUBSIDIARIES
World's Most Complete Refractories Service
GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

BETZ • *A Great Name In Water Conditioning*

Welcome visitor...

The Betz District Engineer is a welcome visitor wherever he goes. As our personal representative to industrial plants, petroleum installations, institutions . . . plants like yours, he plays an all-important role in our continuing efforts to engineer *controlled* water conditioning.

His job carries many responsibilities. For example, he

. . . instructs your plant operators in Betz-engineered water conditioning control techniques (chemical feed, water testing, chemical adjustment, blowdown control, etc.).

. . . makes regularly scheduled visits to your plant to review operating conditions.

. . . reviews plant control and offers "on-the-spot" constructive criticism and advice.

. . . checks testing procedures, test solutions and chemical feed equipment.

. . . inspects plant equipment and visually observes the results obtained.

. . . discusses any and all water problems with you and your operating personnel.

. . . prepares and submits a complete written report before leaving your plant.

And equally important, he works closely with the Betz headquarters engineering staff to assure the individual attention required for sound, economical water conditioning.

Next time a Betz District Engineer calls, ask him to explain how Betz *completely-integrated* water conditioning service can obtain results in *your* plant. He'll be happy to give you the details.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: BETZ Laboratories Limited, Montreal 1.

BETZ

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

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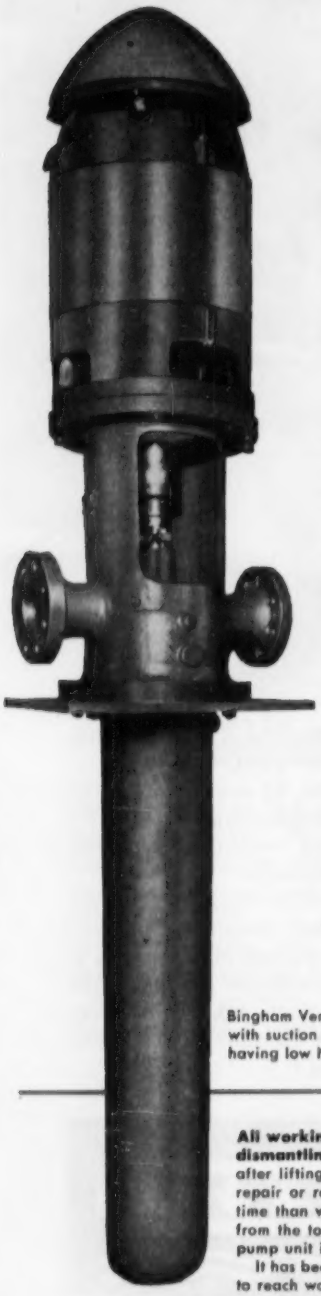
NEW! Bingham ALL WORKING PARTS

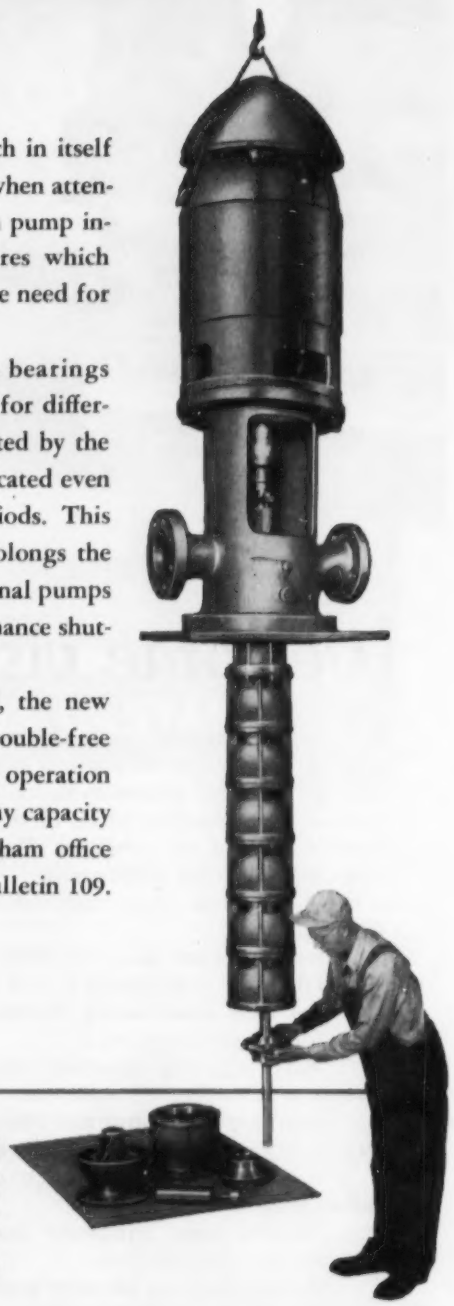


Bingham Vertical VCP assembled with suction well for installations having low NPSH conditions.

Besides bottom dismantling, which in itself greatly reduces maintenance time when attention is required, this new Bingham pump incorporates advanced design features which minimize maintenance, reducing the need for periodic inspection.

For example, all intermediate bearings (supplied of appropriate material for different pumpages) are forced-lubricated by the pumpage. Bottom bearing is lubricated even if the pump runs dry for short periods. This *dependable* lubrication greatly prolongs the life of bearings, which in conventional pumps are frequently the cause of maintenance shutdowns.

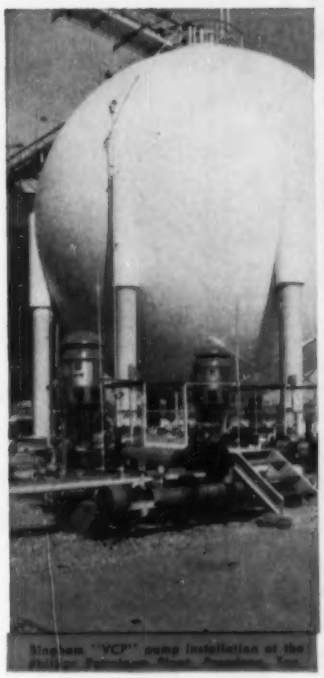
Wherever it has been installed, the new Bingham VCP Pump has given trouble-free service—plus unsurpassed smooth operation with no vibration. Available for any capacity or head. Write your nearest Bingham office for additional information, and Bulletin 109.

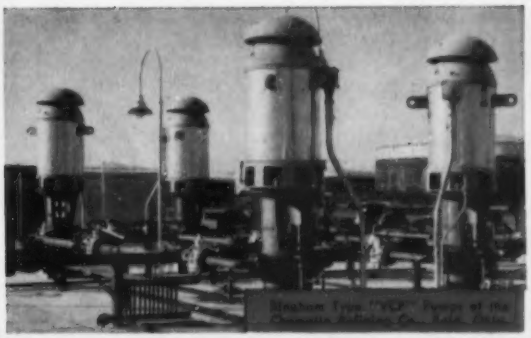


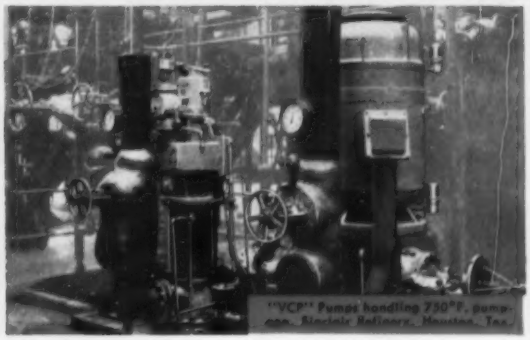
All working parts of pump easily accessible with bottom dismantling. One man can service the Bingham VCP Pump after lifting pump from well. By dismantling from the bottom, repair or replacement of any part can be made in much less time than with conventional pumps (where dismantling begins from the top, necessitating removal of driver and head before pump unit is accessible).

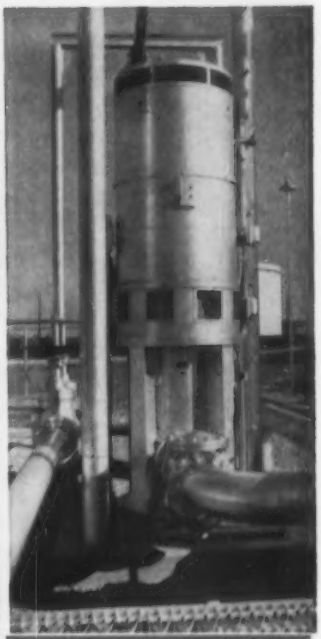
It has been estimated by various operators that time required to reach working parts has been reduced as much as 50%.

VCP VERTICAL PUMP FOR LOW NPSH
ACCESSIBLE WITH BOTTOM DISMANTLING









Partial list of major oil companies with Bingham "VCP" Pumps in operation or on order:

Ashland Oil & Refining Co.	Phillips Petroleum Co.	Chemical Construction Co.
Gulf Oil Corporation	American Cyanamide Co.	Champlin Refining Co.
Sinclair Oil & Refining Co.	ESSO-Standard Oil of N. J.	Pacific Gas & Electric Co.
Sun Oil Company	British American Oil Co., Ltd.	Socony-Vacuum
The Texas Company	Lakehead Pipe Line Co.	Aerojet General Corp.
Imperial Oil Co., Ltd.	Creole Petroleum Co.	Great Lakes Pipe Line Co.
Shell Oil Company	Humble Oil Company	Kaneb Pipe Line
Deere & Company	Standard Oil Co. of Indiana	Buckeye Pipe Line Co.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: 2800 N.W. Front Avenue, Portland 10, Oregon

Factories: Portland, Ore. • Vancouver, B. C., Canada

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HOUSTON, TEXAS — ST. LOUIS, MO.
KANSAS CITY, MO. — ST. PAUL, MINN.
LOS ANGELES, CALIF. — TULSA, OKLA.
NEW ORLEANS, LA. — TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

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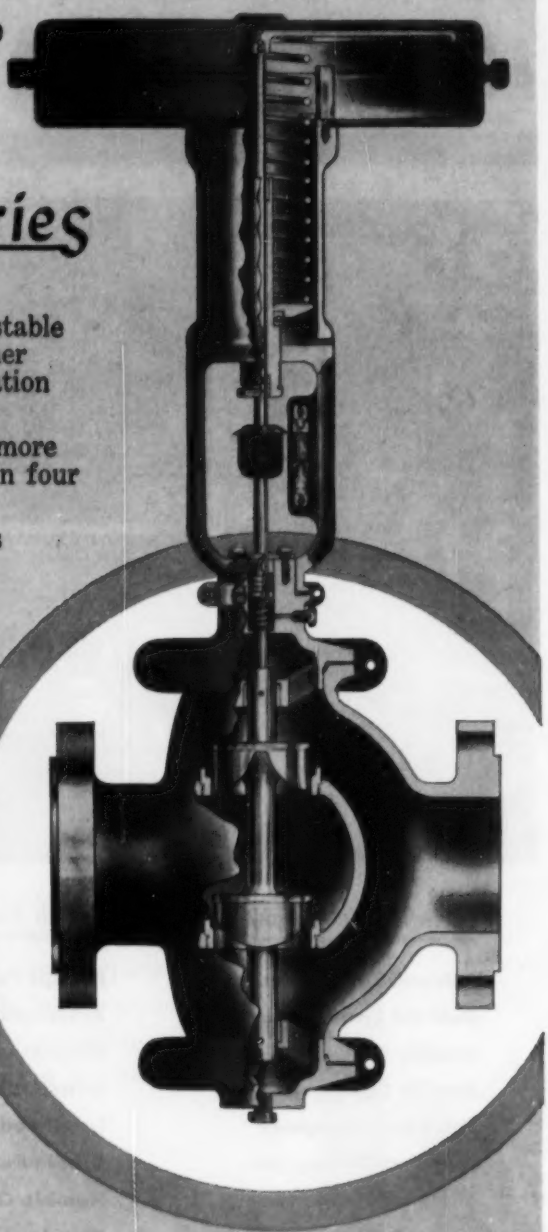
TAKE A GOOD LOOK...

...At The Redesigned Valve Body Of The New BS&B

Super 70 series



NEW — Streamlined flow contours provide more stable flow at all rated differentials and any inner valve position. Turbulence and cavitation are minimized.

NEW — Accurately engineered inner valves give more exacting flow characteristics. Available in four types, top and bottom guided.

NEW — Patented all-metal float ring seal provides positive self-actuating closure... tightens with the application of pressure.

NEW — Forged clamp ring allows yoke orientation to any position. Requires only two bolts... eliminates annoyance of gasket replacements.

Super "70" Series valve bodies are available in three styles... single port, double port and split body for use in erosive or corrosive fluid service where easy removability of valve seat is desirable. All bodies can be reversed without change of parts or special tools. Split and bolted stem connector is strong, easily accessible and quickly assembled. Bolted stuffing box assembly with stainless steel follower includes spring-compressed Teflon as standard packing. Steel bodied valve dimensions are in accordance with ASA Standards B 16.5—1953.

BS&B — EFFICIENCY — OVER 40 YEARS — RELIABILITY — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

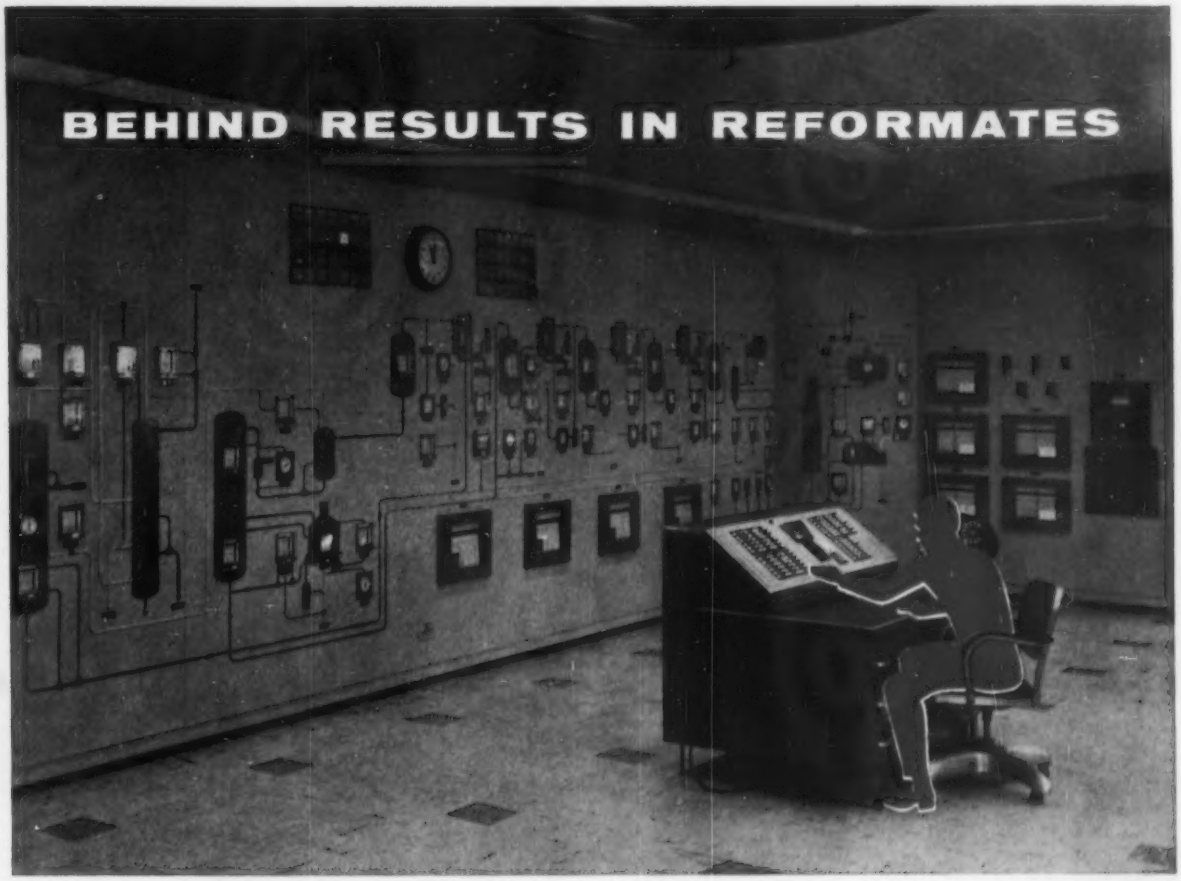
This advertisement highlights features of the Super "70" Series Valve Bodies only. Another will detail features of the Super "70" Series Topworks. Watch for it!

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-F11

7500 East 12th Street

Kansas City 26, Missouri



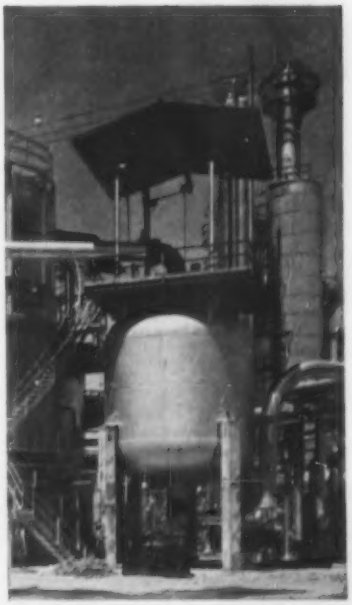
Another Kellogg Example of Engineering Teamwork

Above is the control room for Sinclair Refining Company's modernized refinery at Houston, showing instruments at the right for one of the largest and most efficient cat reformers ever built. Designed for 24,000 BPD of 95 octane clear (101 leaded) on a 3-reactor blocked-out system, this reformer is the result of engineering teamwork between Sinclair Refining Company and The M. W. Kellogg Company. It typifies M. W. Kellogg's ability to work harmoniously with oil refiners toward the optimum solution to a specific refining problem.

This cat reformer is the second to be erected by The M. W. Kellogg Company using Sinclair-Baker regenerative catalyst RD-150. Process and catalyst together provide a new and economical way for Sinclair to increase yields from present feedstocks and to get high octane reformates from low grade naphthas.

Kellogg-designed cat reformers, engineered from the laboratory and pilot plant data of both Kellogg and Sinclair, enable refiners to obtain reformates of 100 octane clear with naphthas from Kuwait crudes, and 102 with naphthas from Mid-Continent crudes. Quick start-up is assured. Cost of catalyst per barrel of reformate is lowered. A major Kellogg contribution is the desulphurization phase of the process, which sharply reduces equipment corrosion and catalyst contamination.

Nine other catalytic reforming units of this process design are now on M. W. Kellogg's drawing boards for major oil refiners. All will yield reformates of 95 octane clear or better.



One of three reactors for the catalytic reformer at Sinclair's Houston refinery.

REFINERY PROCESS DIVISION

The M. W. Kellogg Company

711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Ltd., Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York
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The bigger they come the more you save with ULTRALITE

G-B ULTRALITE DISTRIBUTORS

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AMARILLO, Ball Distributing & Engr. Co.
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CHICAGO, E. C. Carlson Co.
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For obvious reasons, applied cost of insulating tanks, vats and vessels is substantially lower when you use wide blanket rolls of ULTRALITE, the long glass fiber insulation. Equally obvious, the joint-free construction and superior thermal efficiency of ULTRALITE mean **extra** heat savings.

Many successful application techniques have been engineered and all of them save you time, heat and dollars. Write today for complete information on different ways to "wrap your tanks and reap the savings" with ULTRALITE. **MATERIAL IS AVAILABLE FROM YOUR LOCAL ULTRALITE DISTRIBUTOR LISTED BELOW.**

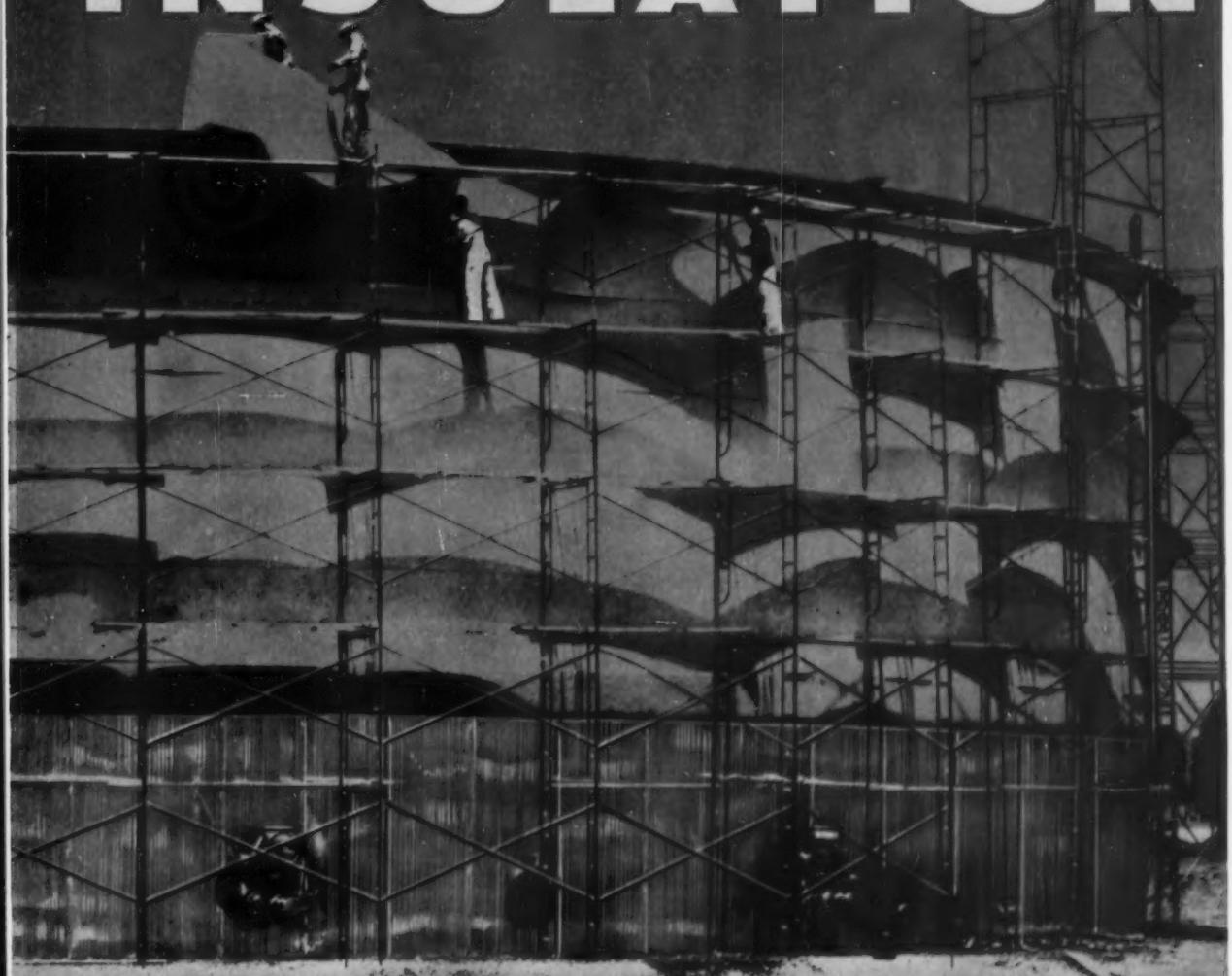
GUSTIN-BACON *Manufacturing Company*

GUSTIN gb BACON

Thermal and acoustical insulations • Molded glass fiber pipe insulation • Pipe coupligns and fittings

242 W. 10th ST., KANSAS CITY, MO.

INSULATION



JACKSONVILLE, Fla., Ferber Sheet Metal Works, Inc.
JOPLIN, Mo., Joplin Cement Co.
KANSAS CITY, Kelley Asbestos Co.
LITTLE ROCK, Gunn Distributing Co.
LOS ANGELES, Western Fibrous Glass Products
Plant Insulation Co.
LOUISVILLE, General Insulation & Roofing Co.
MADISON, Wis., J. D. Wilson Co.
MEMPHIS, John A. Denie's Sons Co.
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NEW ORLEANS, Eagle Asbestos & Packing
NEW YORK, Eastern Steam Specialty Co.
OKLAHOMA CITY, Ball Distributing & Engineering Co.
OMAHA, Cardinal Supply & Mfg. Co.
PHILADELPHIA, John F. Scanlan, Inc.
PITTSBURGH, D. J. Kennedy Co.
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RALEIGH, N. C., Southern States Iron Roofing Co.
RICHMOND, Va., Southern States Iron Roofing Co.
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SALT LAKE CITY, Bullough Asbestos Supply Co.
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SAN DIEGO, Western Fibrous Glass Products
SAN FRANCISCO, Western Fibrous Glass Products
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SCHENECTADY, N. Y., Jon Tree Sales & Supply Co.
SEATTLE, Western Fibrous Glass Products
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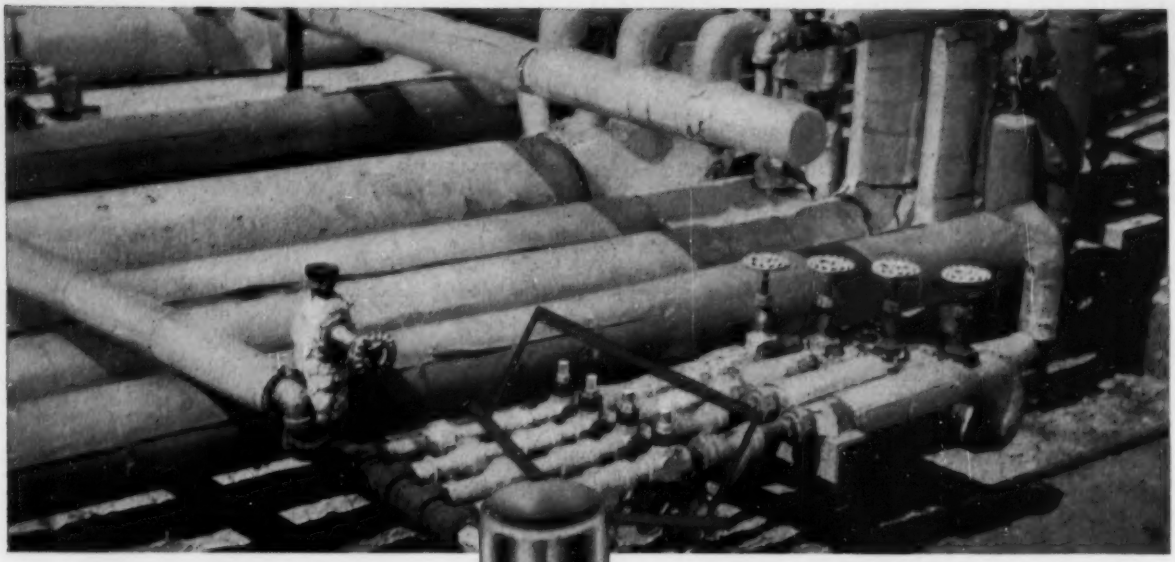
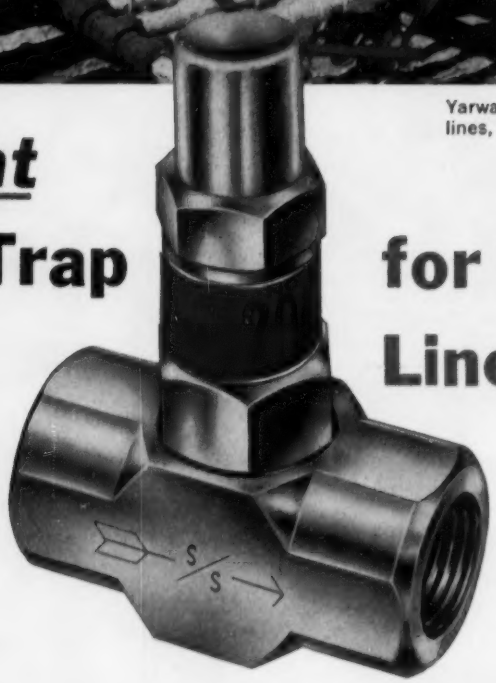
TAMPA, Fla., Eagle Roofing & Art Metal Works, Inc.
TALLAHASSEE, Fla., Capital Refrigeration & Supply
TULSA, Okla., Ball Distributing & Engr. Co.
WASHINGTON, Walter E. Campbell Co., Inc.
WICHITA, General Metals, Inc.
VANCOUVER, B. C., Fleck Brothers Limited



Yarway Impulse Steam Traps on refinery tracer lines, discharging into a common header.

the *right* Steam Trap for Tracer Line Service



● FREE BULLETIN ON STEAM TRACING

If you'd like to have a new, helpful 8-page bulletin dealing exclusively with trapping steam tracer lines, write for "How to Steam Trace". It's free!

The Yarway ½" No. 20-A Impulse Steam Trap is known throughout the processing industries as the right trap for steam tracer lines. The No. 20-A is especially designed for efficient handling of tracers, steam main drips, and other *light condensate loads.*

Small size, light weight, stainless steel construction, only one moving part, maintenance of high even temperatures, and resistance to freeze-ups are distinctive Yarway Impulse Trap features. Well over a million Yarways proved by performance.

Yarways are available through 270 convenient Industrial Distributors. Write for name of one nearest you.

YARNALL-WARING COMPANY 128 Mermaid Avenue, Philadelphia 18, Penna.

YARWAY

impulse® steam trap

The Impulse that revolutionized steam trapping 20 years ago.

The REFINERY ENGINEERING Company's horizons are greatly expanded. Treco is now in position to offer engineering, design and construction of refineries, chemical plants, ore processing, secondary recovery and gas processing facilities on a world-wide basis.

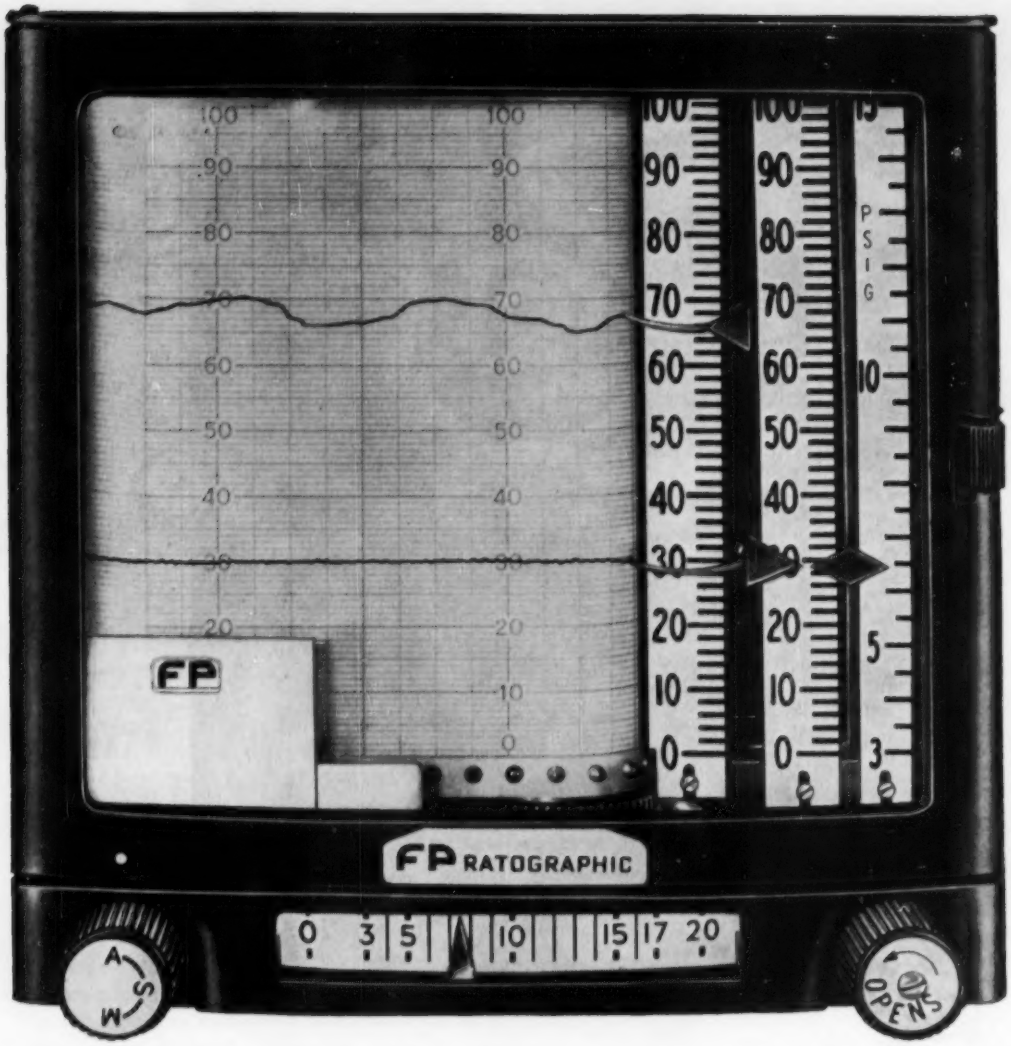
The company has greatly enlarged engineering resources, research and development laboratories and a rapidly expanding staff. This enables The REFINERY ENGINEERING Company to offer a *complete service* to nearly all types of industries.

Treco has just produced a brochure which shows the Company's facilities with photographs of completed projects. A copy will be mailed you promptly upon request on your company's letterhead.

A DIVISION of VITRO CORPORATION of AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO



Fischer & Porter has the answer...it's ***READABILITY***

Look at the actual size illustration above. Notice how horizontal chart travel assures quick, easy readability. Side writing pens mean accurate reading of chart record. The entire instrument may be withdrawn from case, making visible a 14 hour chart section, *without interrupting operation of the recorder or controller in any way*. There are no other instruments like these using full four inch charts.

F&P Ratographic Recorders may be quickly interchanged from the *front* of the panel. Servicing is simple. Automatic seal-off. Consider the continuous chart rewind with handy daily tear-off. Consider the removable pens, fed from an adequate ink supply reservoir. Yes, consider *all* the F&P Ratographic advantages and you'll buy no others.

These instruments mount readily on conventional or graphic panels. Specify any of many options and F&P has the answer. A single F&P Ratographic Recorder in use will convince you of their versatility, high accuracy and dependability. That's a firm assurance. Write today for complete information or specific quotations. Fischer & Porter Co., 1016 County Line Road, Hatboro, Penna.

Illustrated Literature on Request

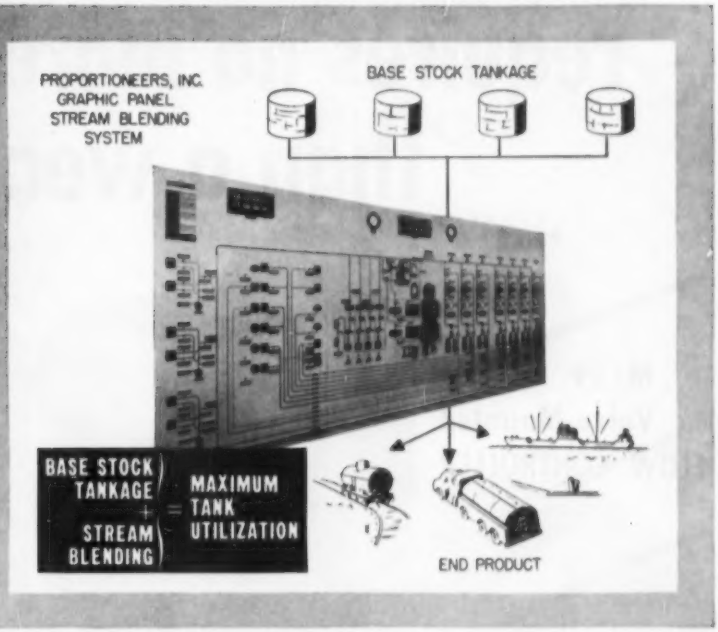
Catalog 55-20 is a complete, detailed report on the multiple applications, the many options available in F&P Ratographic instruments. Write for it today. No obligation, of course.

FP FISCHER & PORTER CO. Hatboro, Pa.

COMPLETE PROCESS INSTRUMENTATION

For more data on advertised products, use Readers' Service Cards, last page.

THE OCTANE EQUATION



THE PROBLEM

As automobile manufacturers continue their current trend toward higher-compression engines, refiners face an ever increasing demand for premium motor fuels. New processes, or improvements on existing processes, are being installed to meet these demands. The fuel outlook is further complicated by the fact that the automotive industry is developing engines requiring lower grade fuels . . . and predictions indicate these engines will be in use by 1960.

THE SOLUTION

The fast growing petroleum industry is quick to recognize and adopt equipment which facilitates product movement . . . and continuous automatic blending gives refinery operation the flexibility it needs to keep pace with progress. Stream blending not only provides tailor-made hydrocarbons, but minimizes the need for intermediate tankage and allows specific seasonal market conditions to be met without costly inventory change-overs. B-I-F Industries, Inc. is the leading manufacturer of this type of equipment . . . and boasts the greatest number of diversified installations.

Features

★ *Complete stream blending systems, utilizing unitized construction, are available . . . factory-tested under field conditions.*

★ *All systems are electrically and mechanically interlocked to provide "fail-safe" operation under all job conditions.*

★ *Our "Blue Chip" products are designed, engineered, manufactured, assembled and tested . . . under one roof . . . assuring you of outstanding product quality and performance.*

"THE BEST COSTS LESS"

For engineered recommendations, write to Proportioneers, Inc., Division of B-I-F Industries, Inc.

B-I-F INDUSTRIES

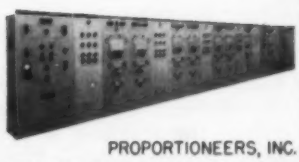
PROVIDENCE, RHODE ISLAND

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • BUILDERS-PROVIDENCE, INC. • OMEGA MACHINE CO.

METERS
FEEDERS
CONTROLS

TECHNICAL DATA

Shell Products Pipe Line was one of the first to recognize the flexibility of operation made possible by continuous automatic "stream" blending. This company has installed B-I-F Industries' equipment at their Wood River Pump Station for blending finished gasolines directly to their North and East lines respectively. Preset formulations at all flow rates of finished product demanded by the pipeline are automatically maintained by multiple component blenders . . . to blend six gasoline base stocks, T.E.L., dye, and gasoline additives to pipe lines without intermediate tankage. Full particulars on this installation are available



PROPORTIONEERS, INC.
STANDARD PANEL STREAM BLENDER

This equipment can be arranged to handle any type of problem and any number of components at flow rates ranging from 180 barrels per hour to the limit of modern transfer pumping equipment and pipe line sizes.

Units are available for stream blending other finished products (solvents, diesel fuels, lube oils, heating oils, bunker fuels, asphalt cut-backs, etc.) with equal facility and dependability. Our diversified product line . . . for metering, feeding and controlling any of the petroleum or petrochemical processes . . . is designed to make money for you. Let us show you how!

This Controller requires no more attention than a weathervane!

Like a weathervane, the Foxboro M/59 Consotrol Controller can be installed completely exposed to the elements . . . and forgotten about! Unsurpassed in performance by any other flow controller, the M/59 is *completely indifferent to weather conditions.*

This rugged Flow Controller mounts directly on the air connection of the valve . . . at a fraction of usual installation cost. Its case is tightly gasketed, continuously purged, completely weatherproof, highly resistant to dust, fumes, and vibration. There's nothing to align, nothing to wear out. A flexure-strip fulcrum eliminates the friction and wear of conventional pivots . . . eliminates "conventional" maintenance.

In operation, the M/59 fully utilizes the speed and sensitivity of the Foxboro d/p Cell Flow Transmitter . . . does away with transmission lag . . . gives fastest recovery from process upsets. For the *complete* story, write today for Bulletin 470.

"Live-Balance" Control on any fluid with any size valve motor.

Lowest first cost. Lowest installed cost.

Lowest maintenance cost.

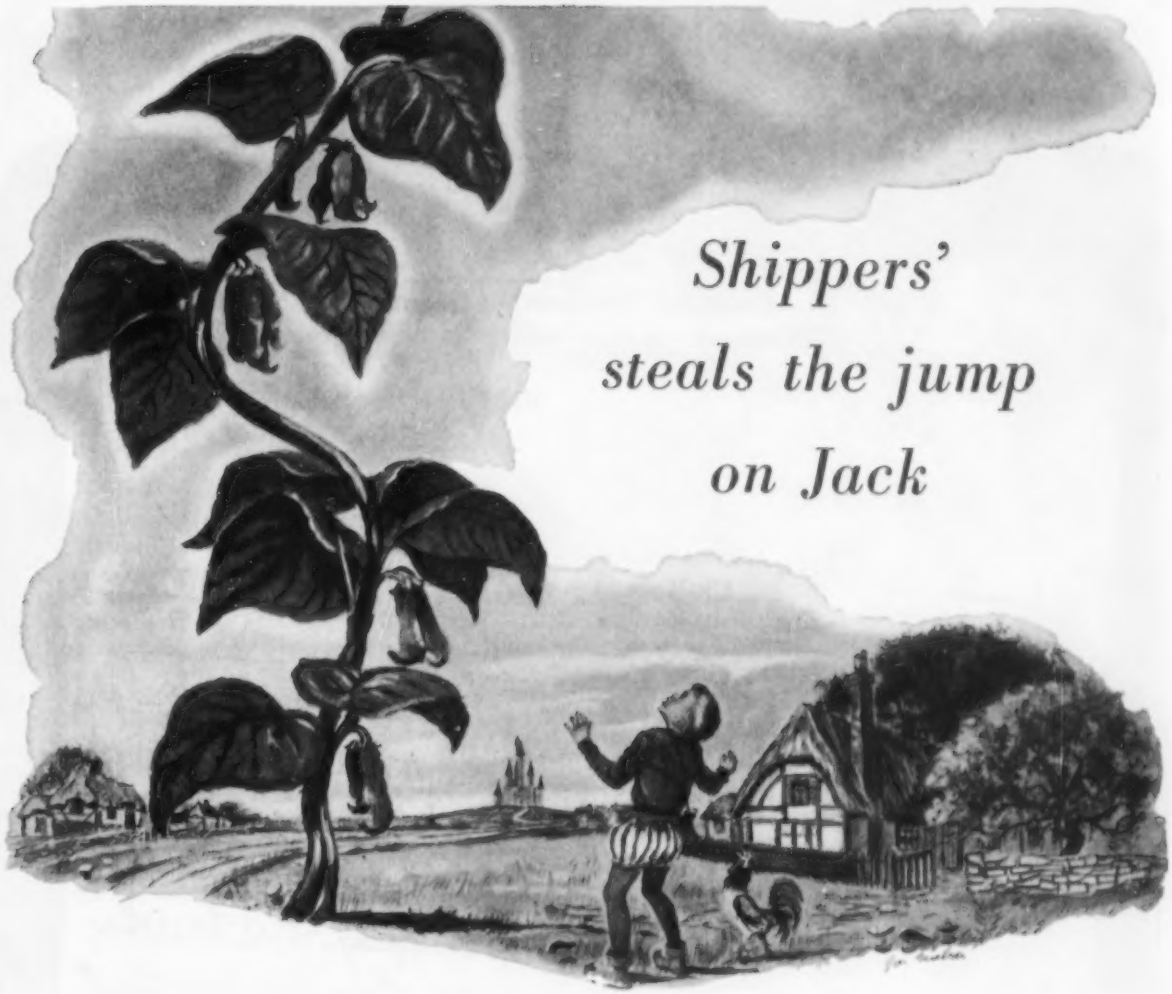
Unique Simplicity — exclusive design permits fixed, optimum proportioning and reset values for liquid flows. Adjustable reset optional for gas or steam flow.

THE FOXBORO COMPANY, 7411 NEPONSET AVENUE, FOXBORO, MASS., U.S.A.

FOXBORO REG. U. S. PAT. OFF. **FLUID FLOW CONTROLLERS**

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

For more data on advertised products, use Readers' Service Cards, last page.



Shippers' steals the jump on Jack

Typical DURADOME . . . designed for vinyl acetate service.

Story-book magic may be all right for growing beanstalks, but it takes a lot more than "abracadabra" to make a tank car fleet grow.

Among other things, it takes planning, organization and not a little vision. But above all, it calls for the kind of *dependable* service which we have been delivering for 35 years. That's why so many leaders in American industry rely on Shippers' for modern tank car service.

For instance, since 1952, the number of Shippers' tank cars has increased more than 20%. That's a growth unparalleled in the industry, and makes Shippers' the fastest growing fleet on the rails!

As exclusive sales agent and lessor for acf built DURADOMES, we'll be glad to help you determine the comparative advantages of rental or outright purchase. There's no obligation.

SHIPPERS CAR LINE SHPX

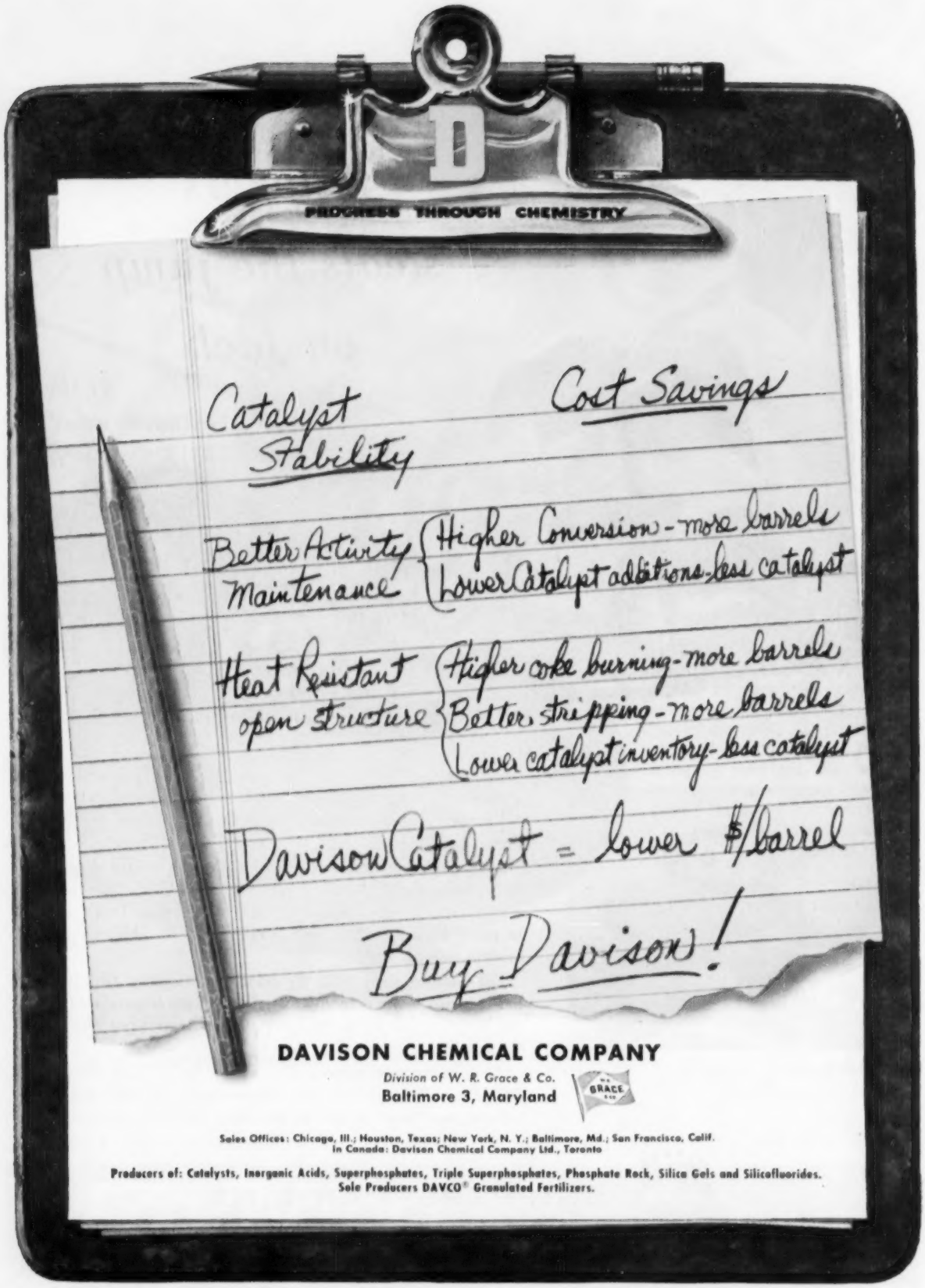
SHIPPERS' CAR LINE

Division of acf INDUSTRIES, Incorporated

30 Church Street, New York 7, N. Y.

CHICAGO, ILL. · HOUSTON, TEX. · SAN FRANCISCO, CAL. · MILTON, PA. · EAST ST. LOUIS, ILL. · CLEVELAND, OHIO · SMACKOVER, ARK. · TULSA, OKLA. · NORTH KANSAS CITY, MO. · RED HOUSE, W. VA.

For more data on advertised products, use Readers' Service Cards, last page.



DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland

Sales Offices: Chicago, Ill.; Houston, Texas; New York, N. Y.; Baltimore, Md.; San Francisco, Calif.
In Canada: Davison Chemical Company Ltd., Toronto

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels and Silicafluorides.
Sole Producers DAVCO® Granulated Fertilizers.

SOLID WHEEL

spells non-stop turbine performance

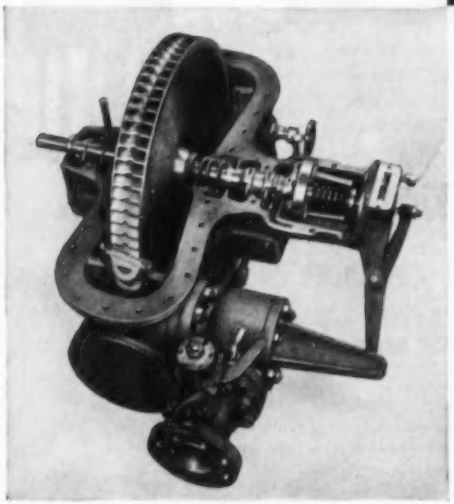
It's easy to see why Terry solid-wheel turbines have been setting non-stop records. They're built for long periods of continuous service.

The rotor, for example, is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to loosen or work out.

What's more, the blades can't foul. There is a one-inch clearance on either side of the wheel and the blades are double rim protected. There is no need for close axial blade clearance, because the steam enters the buckets at right angles to the shaft.

You, too, can profit from Terry solid-wheel stamina. Bulletin S-116 gives full details. Send for a copy today.

THE TERRY STEAM TURBINE CO.
Terry Square, Hartford 1, Conn.



Action of steam in a Terry solid-wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

TT-1205

TERRY

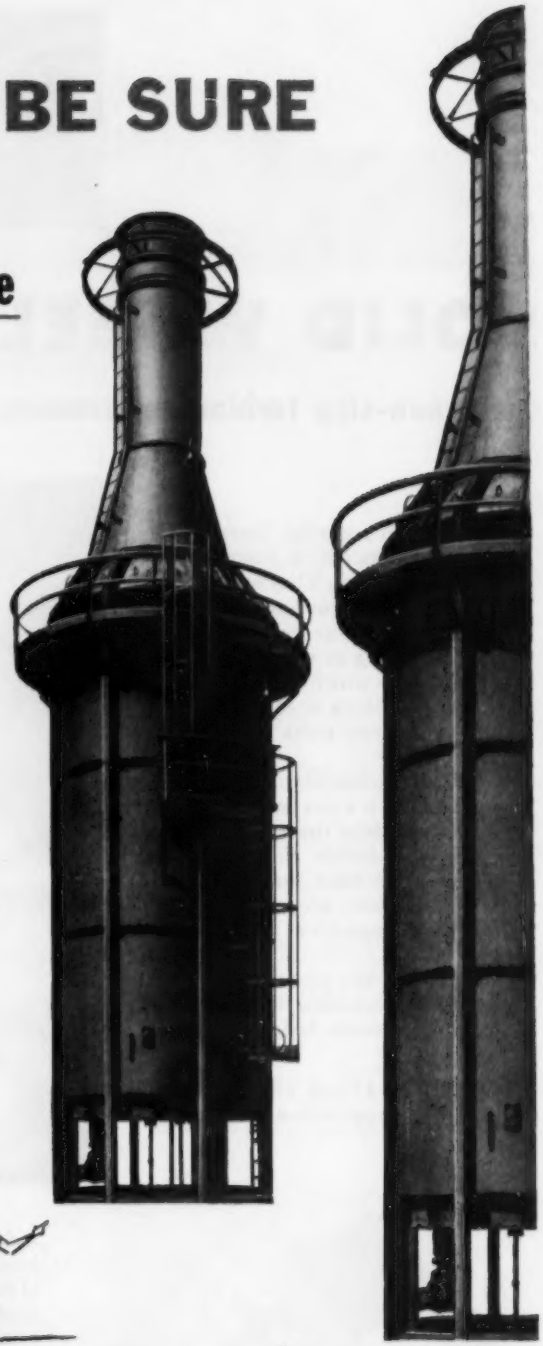
For more data on advertised products, use Readers' Service Cards, last page.

YOU, too, CAN BE SURE

petrochem-isoflow furnaces

are most economically desirable

by any comparison



Whenever *all* the specifications and *all* the operating requirements are applied to direct-fired furnace design, you can be sure PETROCHEM-ISOFLOW FURNACES will be found most economically desirable, by any comparison.

In making comparisons it is essential to take these factors into consideration:

1—Average radiant transfer rate.
2—Maximum deviation from average radiant transfer rate.
3—Average and maximum transfer rate in convection section.
4—Maximum tube wall temperature, radiant or convection.
5—Maximum efficiency with specified excess air.
6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube.
7—Overload and corresponding transfer load.
8—Design to provide: structural column supports—Ladders—Platforms—Tube Removal facilities, etc.
9—Degree of assembly; of the furnace structure and of the heating surface.

When you specify PETROCHEM-ISOFLOW FURNACES . . . you'll be in good company. More than 1500 are now in service, performing to the complete satisfaction of their operators and usually well beyond their rated capacities.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES:

Rawson & Co., *Houston* • Wm. H. Mason Co., *Tulsa* • Lester Oberholtz, *Los Angeles* • Faville-Levally, *Chicago* • D. D. Foster, *Pittsburgh* • Turbex, *Philadelphia* • Flagg, Brackett & Durgin, *Boston* • G. M. Wallace & Co., *Denver & Salt Lake City*

International Licensees and Representatives: SETEA–S.A. Comercial, Industrial, y de Estudios Tecnicos, *Buenos Aires, Argentina* • Industrial Provesdora, *Caracas, Venezuela* • Societe Anonyme Huertey, *Paris, France* • Societe Anonyme Belge, *Liege, Belgium* • Huertey Italiana S.P.A., *Milan, Italy* • Birwelco Ltd., *Birmingham, England*

KEY 5000 Type Return Bend Fittings Serving on Heaters in World's Largest Refinery Still

Gulf Oil's Philadelphia refinery, a sprawling giant on the Schuylkill River, is the home of the world's biggest atmospheric and vacuum still, and contains one of the largest heaters ever built. The heater alone covers 8,000 square feet and consumes 2,000 barrels of fuel oil each day.

Serving this massive heater are new KEY 5000 Type Return Bend Fittings. Simple in design, rugged in construction, they provide dependable and lasting service at real economy. The 18 fittings in two series contain only 26 parts instead of the usual 72 in other fittings of this type. Inventory space and cost are thus substantially reduced.

KEY 5000 Type Fittings can bring this dependability and economy to your processing, too. All parts except casting are available for immediate shipment.

W-K-M Manufacturing Company, Inc.
A SUBSIDIARY OF acf INDUSTRIES INCORPORATED
PLANT: MISSOURI CITY, TEXAS • MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

MANUFACTURING

KEY RETURN BENDS AND FITTINGS

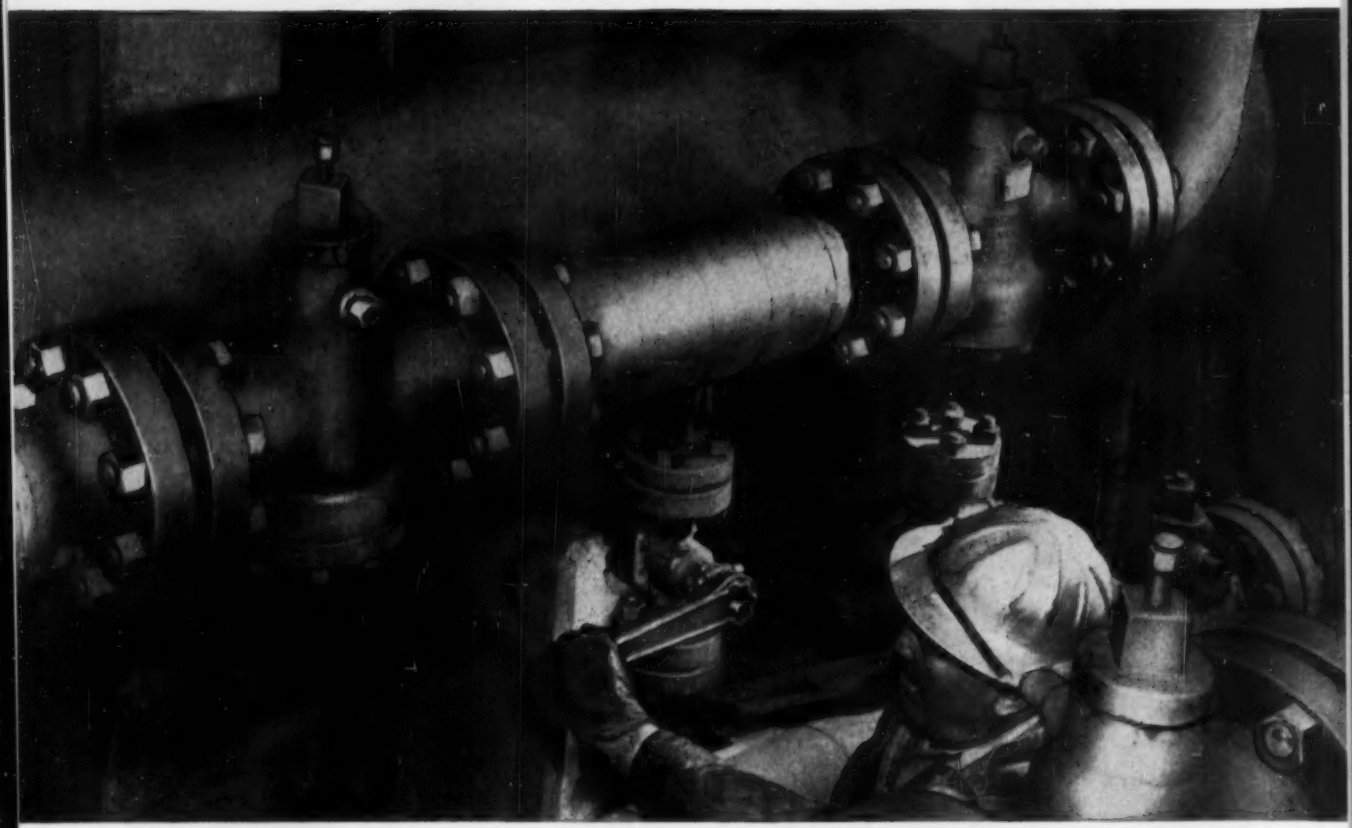
W-K-M THROUGH-CONDUIT GATE VALVES

acf LUBRICATED PLUG VALVES

For more data on advertised products, use Readers' Service Cards, last page.

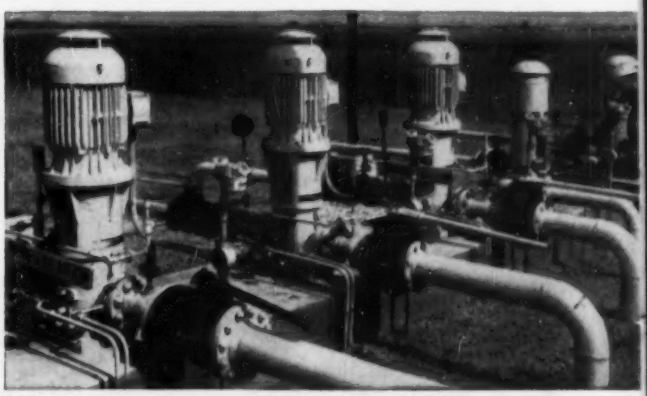
Where There's No

ROCKWELL-Nordstrom



Rockwell-Nordstrom lubricant sealed valves *stay* leakproof in polymerization plant service.

For refinery transfer lines, Rockwell-Nordstrom valves close with fast, easy, quarter-turn operation.



At gasoline plants, Rockwell-Nordstrom valves can't be matched for safety on light hydrocarbon services.

Time For Down-Time

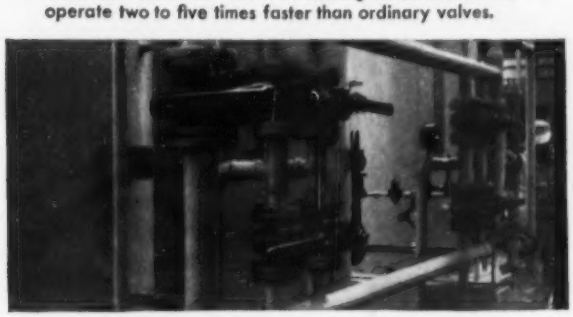
VALVES Perform Better, Longer, For Less Money

One good way to cut costly down-time in "round-the-clock" process units like refineries and gasoline plants is to use Rockwell-Nordstrom valves. That's why so many oil and gas companies standardize on Rockwell-Nordstrom valves where flow control *must* stay dependable and safe month after month.

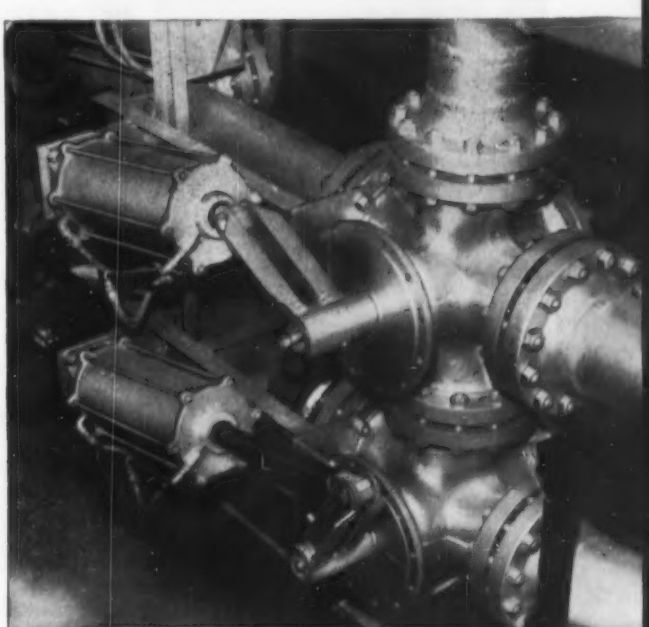
The reason for the greater dependability and safety of Rockwell-Nordstrom valves is *pressurized lubricant.* This forms a leakproof seal for tightest shut-off and jacks the plug for fast, easy quarter-turn operation. Lubricant also cuts maintenance costs and adds years to valve life by eliminating grinding metal-to-metal wear.

The original and world's most complete line, Rockwell-Nordstrom lubricated plug valves cost no more to buy—and far less to use—than any other valve. Available in WOG ratings to 10,000 lb. and sizes to 30 x 34" in steel, stainless, semi-steel and corrosion resisting metals. Write for more details: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee:* Peacock Brothers Limited.

Rockwell-Nordstrom valves on cooling tower water lines operate two to five times faster than ordinary valves.



Rugged design and unexposed seating in Rockwell-Nordstrom valves prevent pump shock load wear on glycol circulation service.



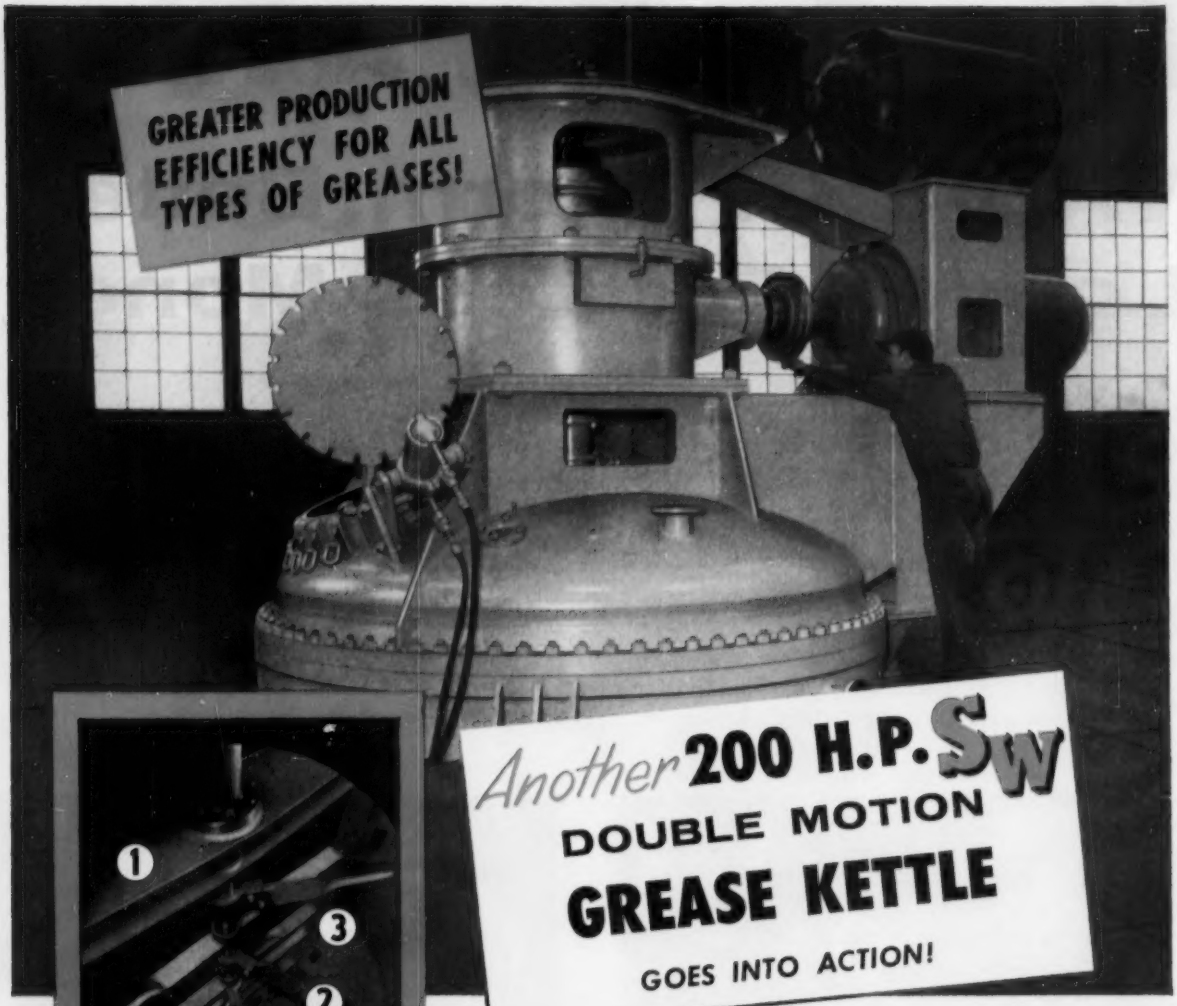
These air operated 4-way Rockwell-Nordstrom Multiport valves on cat reformer stills make control of recycle gas lines fast and dependable.

ROCKWELL-Nordstrom VALVES

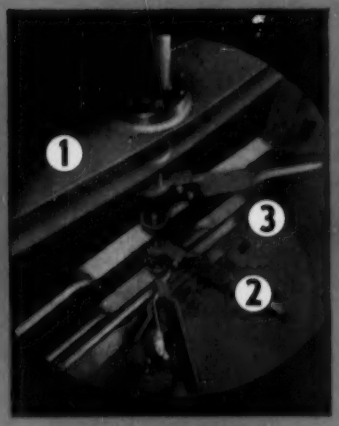
Lubricant Sealed for Positive Shut-off

40th YEAR *of lubricated plug valve leadership*

For more data on advertised products, use Readers' Service Cards, last page.



Another 200 H.P. SW DOUBLE MOTION GREASE KETTLE GOES INTO ACTION!



1. Heavy duty, scraper frame with rugged paddle arms for high H.P. input.
2. Counter-rotating de-stratifying arms of extremely heavy construction for high H.P. input.
3. Hinged scraper blades contact 98% of inside surface for the ultimate in heat transfer efficiency.

Farsighted management at this petroleum products plant is expanding with SW equipment to achieve peak production from a single investment. SW's "double motion" mixing equipment gives fast, efficient, and thorough grease processing that will automatically increase your product yield. SW Grease Kettles can be supplied in steel or alloy material and can be designed for direct fire or steam jacket heating. Send us your mixing problem!

STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

MACHINERY DIVISION

MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

STRUTHERS WELLS Corporation

WARREN, PA.

Struthers Wells

Plants at Warren, Pa. and Titusville, Pa.

Offices in Principal Cities

How it Works!

Only new Sarco TD steam trap uses kinetic energy of steam to close valve

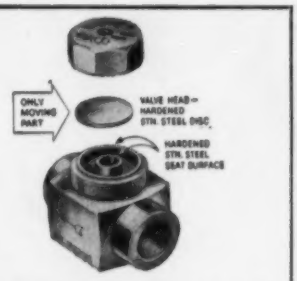
GAS MANTLES have been replaced by electric lights, steam locomotives by diesels, propeller planes by jets.

Now, the use of the kinetic energy of steam principle gives us a modern type of steam trap.

The Sarco TD obsoletes all other types for most 10 to 600 psi installations. For example, it operates without a valve closing device—no bucket, float, bellows, pins, levers or gaskets.

Glance below and you'll agree that no other steam trap is even similar to the Sarco TD!

For a trial installation—write today.



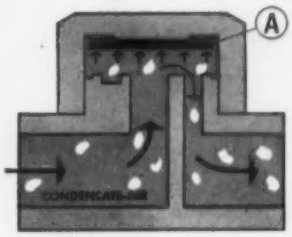
Only 3 parts... all stainless steel

Sizes ⅜ to 1"—each body is as small as a tee fitting! Capacity is determined not by a bulky body but by the effective orifice, valve action, pressure drop and condensate temperature.

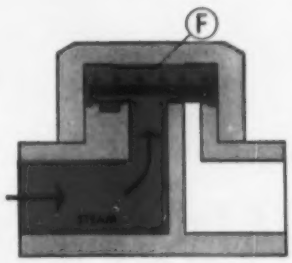
Many Advantages

1. *Practically no maintenance*—no valve mechanism, no narrow channels. Trouble-free simple design. Only 3 parts—all stainless steel.
2. *One trap for all pressures*—self-adjusting. One large capacity seat for 600 psi as for 10 psi. No changes or adjustments.
3. *Operates equally well on all loads*—on heavy, light or no condensate load. No prime to lose. No adjustments.
4. *No steam leak required*—to operate the Sarco TD. Closes tight against steam.
5. *Discharges at steam temperature and vents air* and air-steam mixtures at start-up and during operation.
6. *Freeze-proof*—when installed with outlet down, free to drain.

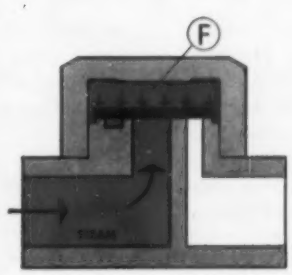
Only Sarco TD Thermodynamic Steam Trap Uses This Unique Operating Principle Which Permits Trouble-Free TD Design



1. Inlet pressure raises disc "A" from seat... immediate discharge of air and condensate at steam temperature.



2. Steam follows the condensate and the high velocity jet across the bottom of disc "A" creates a low pressure area (Bernoulli effect)... the jet is deflected into chamber "F" where it builds up pressure by recompression and this pressure acts on the top of the disc "A"...



3. Pressure in chamber "F", acting on full top area of disc "A", exceeds force of incoming steam and low pressure area under the disc... and immediately forces it down, closing the inlet. As condensation decreases the pressure in chamber "F", the disc rises and steps 1 or 2 repeat.

60-day trial convinces... No obligation... Use coupon!

SARCO

Steam Traps—Temperature Regulators—Strainers—Heating Specialties

SARCO COMPANY, INC., Empire State Bldg., New York 1, N. Y.

Please send me Sarco TD Steam Trap and strainer for 60-day trial. Size_____

For installation on_____

Name_____ Title_____

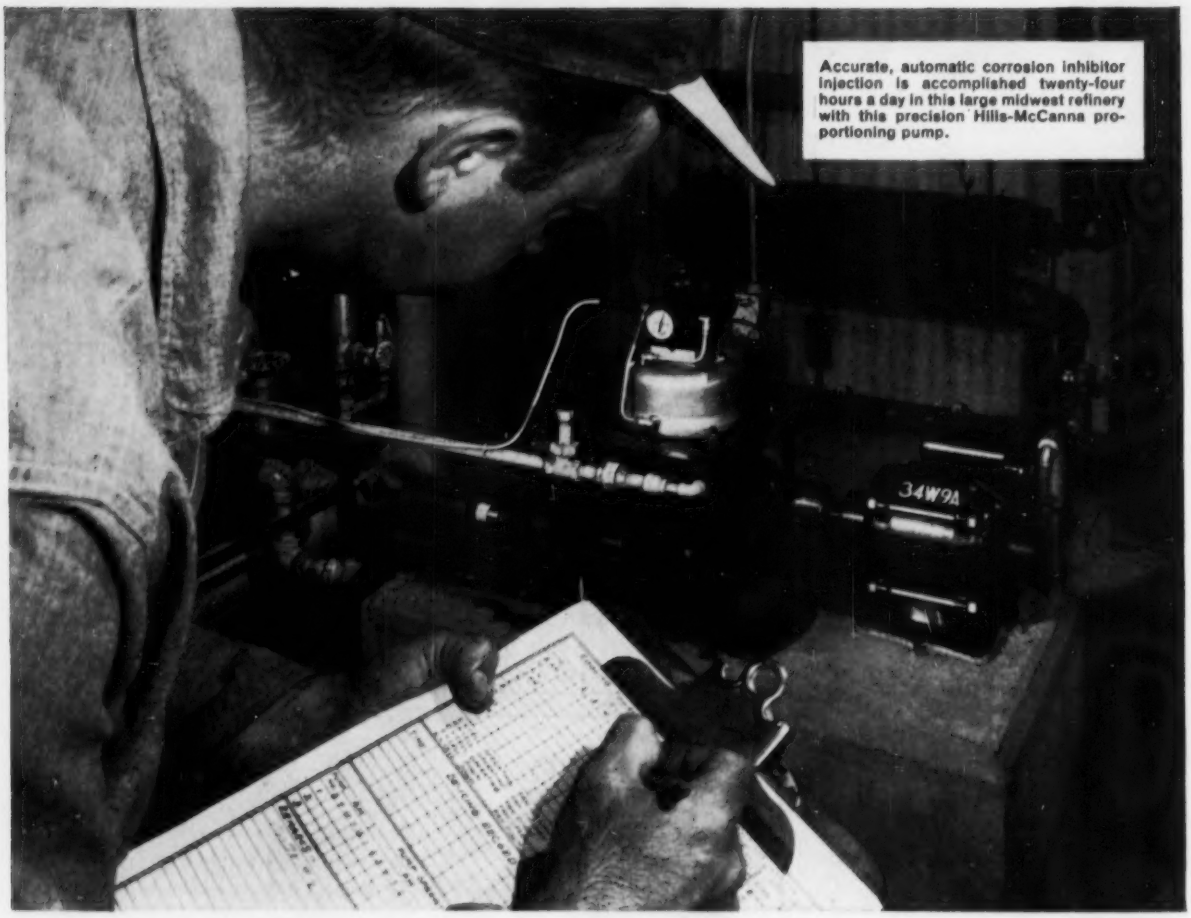
Firm_____

Address_____

City_____ State_____

8184-C

For more data on advertised products, use Readers' Service Cards, last page.



Accurate, automatic corrosion inhibitor injection is accomplished twenty-four hours a day in this large midwest refinery with this precision Hills-McCanna proportioning pump.

Chemical Metering 24 hours a day...Automatically!

Pre-set to automatically respond to a signal from a master control panel, this Hills-McCanna precision chemical metering pump automatically injects a corrosion inhibitor into make-up water. Constant setting and adjusting is safely eliminated. Pneumatically controlled, this pump is just one of several Hills-McCanna pumps used by this large midwestern refinery for day-in, day-out, completely automatic and accurate proportioning service. Low maintenance is assured by the pumps' straight line drive action.

Automatically controlled stroke adjustments and variable speed drives are available for Hills-McCanna metering and proportioning pumps. Either pneumatic or electrical actuating controls may be used. Some applications involving automatic controls are pH, temperature, and liquid level control, as well as proportional flow response.

Automatic control recommendations will be furnished whenever requested. Call a Hills-McCanna engineer today for complete details on the many possible control devices available – and make sure you ask for the new, complete catalog listing all Hills-McCanna precision metering and proportioning pumps.

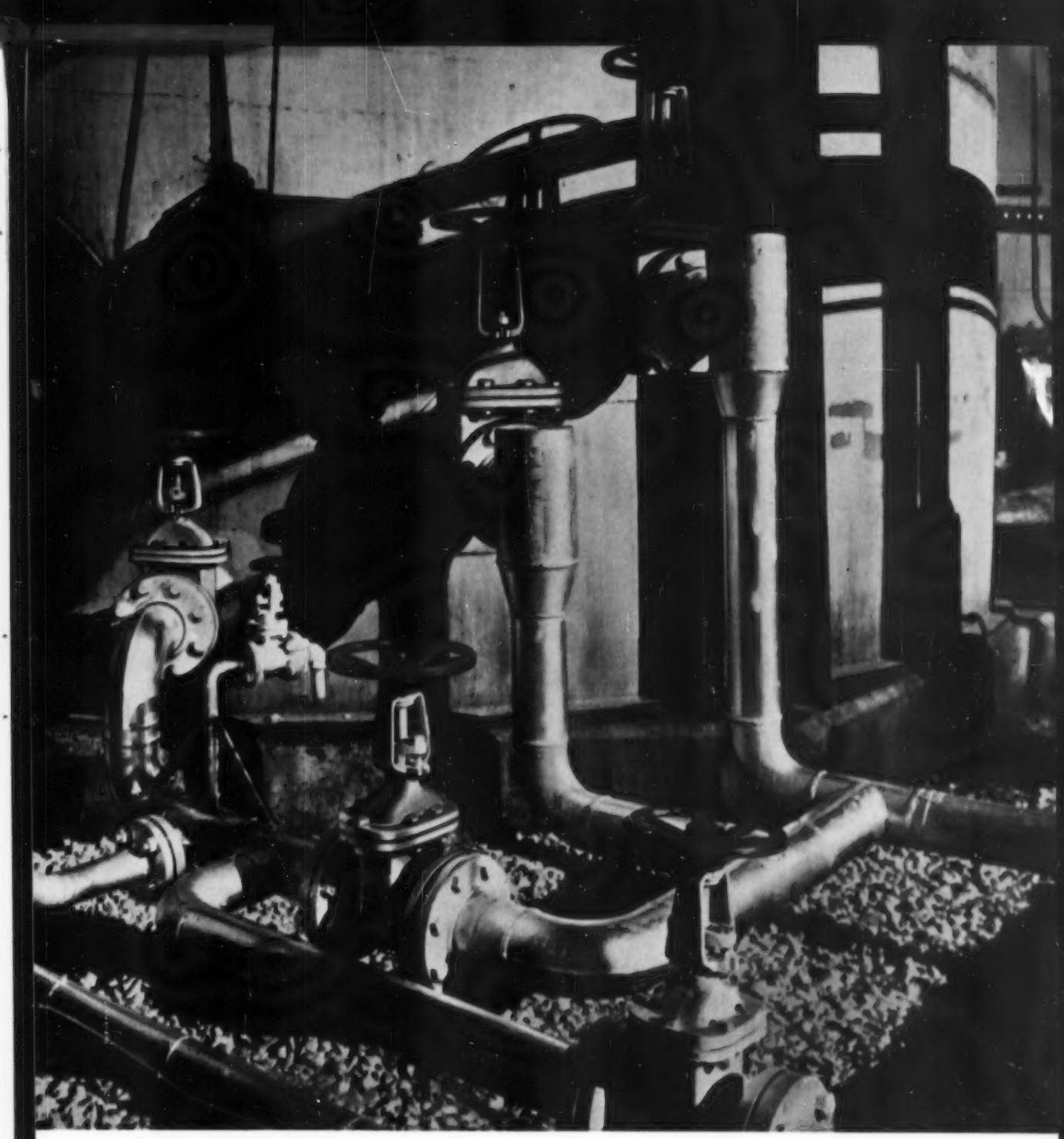
Call or write today for this new catalog.

HILLS-McCANNA COMPANY

2441 W. Nelson, Chicago 18, Illinois

METERING AND PROPORTIONING PUMPS • DIAPHRAGM VALVES • FORCE FEED LUBRICATORS • LIGHT ALLOY CASTINGS

For more data on advertised products, use Readers' Service Cards, last page.



Meet three synthetic detergent experts

You're looking at a Philadelphia installation of The Atlantic Refining Company (expert #1).

Ultrawet, an important ingredient of synthetic detergents, is the product being processed in this modern plant designed and built by The H. K. Ferguson Co. (expert #2).

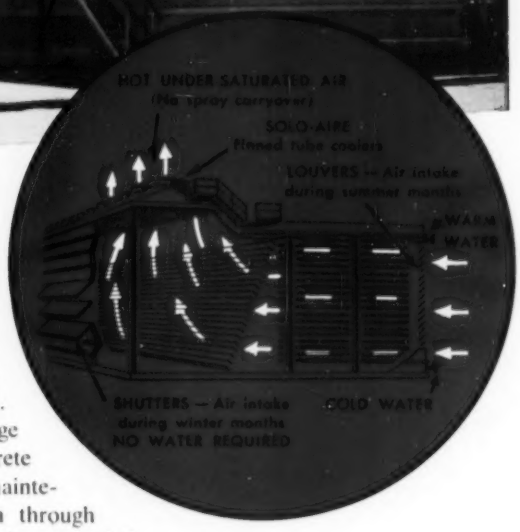
Helping to prevent contamination of the product due to corrosion are long-lasting, red-wheeled valves made by Aloyco (expert #3). Made of corrosion-resistant Aloyco 20, the gate and globe valves used here handle a 98% concentration of sulfuric acid at up to 180° F.

Whatever your process, whichever corrosives you need to keep in line, it pays to check first with Aloyco. As the world's largest manufacturer of corrosion-resistant valves exclusively, we're most likely to have the valve you need. Write Alloy Steel Products Company, Inc., 1301 West Elizabeth Ave., Linden, New Jersey. 63

Subsidiary of Walworth Company

HUDSON Combin-aire

LOW TEMPERATURE COOLING USING COMBINATION OF MINIMUM WATER AND MAXIMUM AIR



Where quantity or quality of water is low, and ambient air temperatures too high to permit direct cooling with air, process plant designers find the modern solution in Combin-aire. In addition to large savings through minimizing water consumption and eliminating water treatment, Combin-aires incorporate many other advantages.

The Combin-aire pictured above, installed in a large gas processing plant in northern Mexico, is of concrete construction, eliminating fire hazard and minimizing maintenance. As shown in the cut-away drawing, air is drawn through cooled water by fans located on top of the structure. The air, precooled and washed free of solids by the water, flows across the finned tube coolers, and leaves the top of the Combin-aire at elevated temperature under-saturated with water vapor. Mist carryover, condensation from effluent air, and air recirculation are thus eliminated. Combin-aires are installed adjacent to process equipment, minimizing piping and concentrating operating area.

In winter, air flows directly to the Solo-aire finned coolers, water circulation being unnecessary. Where water is required for shell and tube units or atmospheric sections, such water may also be cooled in the Combin-aire unit, eliminating the conventional cooling tower.

In addition to Combin-aire units, Hudson manufactures water cooling towers, air-cooled and water-cooled coolers and condensers, and is experienced in plant layout, piping, and water treatment. We shall be glad to assist prospective plant owners in making overall comparisons of first costs and operating costs for complete cooling systems using various combinations of equipment.

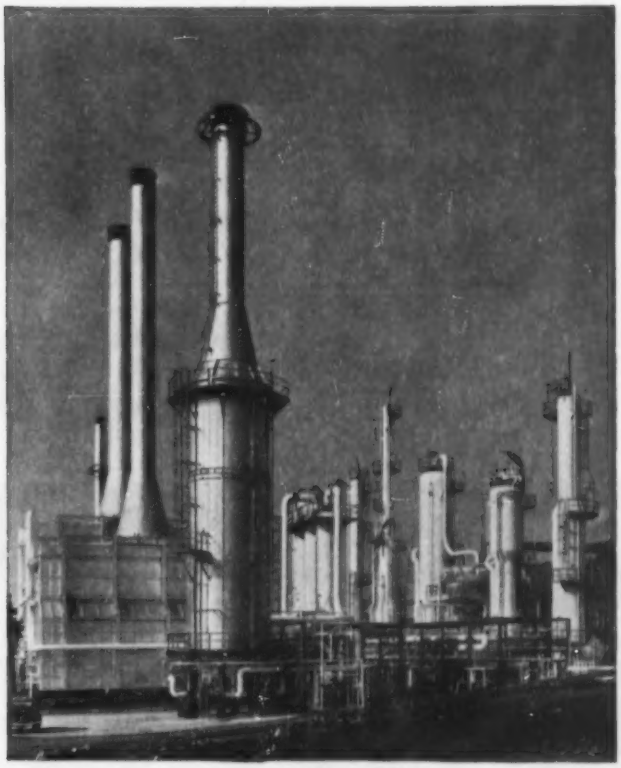
HUDSON

ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

405 Lexington Ave., New York 17, N. Y. • 2500 W. Sixth St., Los Angeles 57, Calif. • Corrientes 1115, Buenos Aires, Argentina

INTERESTED IN UNIFINING* FOR DESULFURIZATION AND UPGRADING



• Unifining Unit
Union Oil Company of California refinery
Oleum, California

UNIFINING should be of particular interest to all operators of catalytic reformers which produce by-product hydrogen.

• Harshaw is the exclusive producer of the Union Oil Company of California cobalt-molybdate catalyst used in the recently announced "Unifining" desulfurization and upgrading process. This rugged, commercially proven catalyst is supplied in the form of cylindrical tablets conforming to rigid physical and chemical specifications established by Harshaw and Union Oil Company of California. Stability at high temperatures permits repeated regenerations if and when necessary.

Please contact Harshaw for further information on this catalyst.

HARSHAW

THE HARSHAW CHEMICAL CO.

1945 East 97th Street, Cleveland 6, Ohio

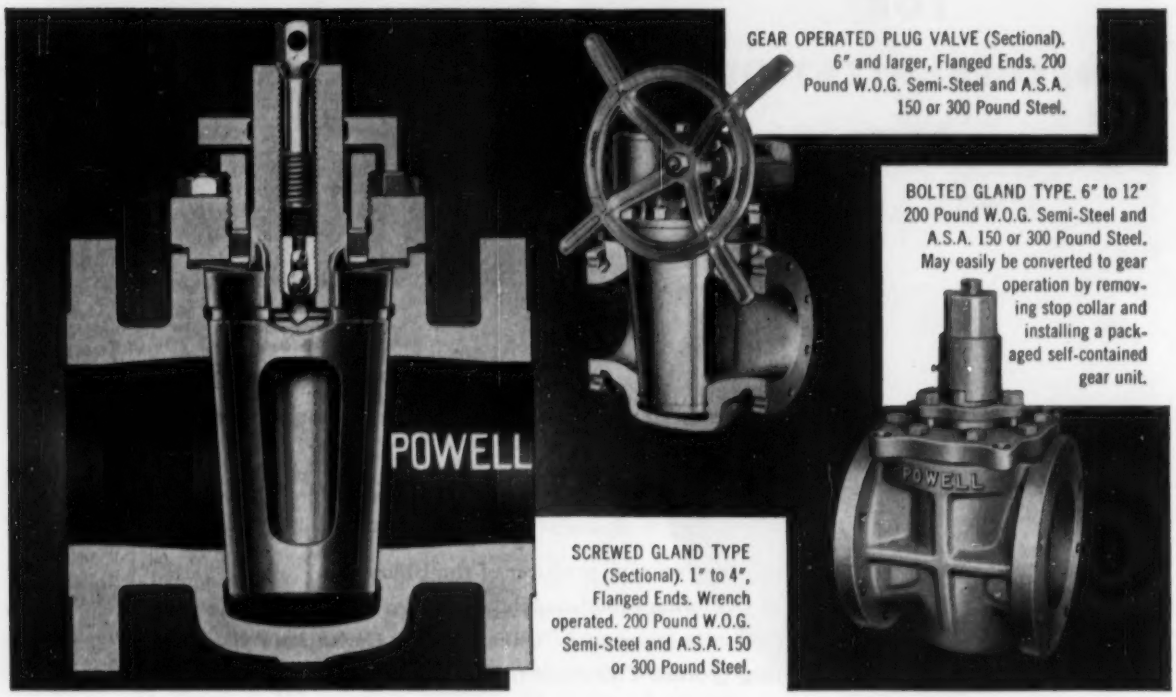
Chicago 32, Illinois • Cincinnati 13, Ohio • Detroit 28, Michigan • Hastings-On-Hudson 6, N. Y.
Houston 11, Texas • Los Angeles 22, California • Philadelphia 48, Pennsylvania
Pittsburgh 22, Pennsylvania

* Trademark of Union Oil Company of California

For more data on advertised products, use Readers' Service Cards, last page.

POWELL

Lubricated Plug VALVES



GEAR OPERATED PLUG VALVE (Sectional). 6" and larger, Flanged Ends. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

BOLTED GLAND TYPE. 6" to 12" 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel. May easily be converted to gear operation by removing stop collar and installing a packaged self-contained gear unit.

SCREWED GLAND TYPE (Sectional). 1" to 4", Flanged Ends. Wrench operated. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

Powell Lubricated Plug Valves maintain our 110-year tradition of quality and precision. Only the finest available materials are used. And painstaking quality control is rigidly enforced through each and every step of manufacture.

Features include quick and positive operation—just a quarter-turn to open or close. Lubricant grooves surrounding each port provide a positive seal when the valve is closed. In an open position, seating surfaces are not exposed.

Valve users who want one source of supply for lubricated plug as well as all types of bronze, iron, steel and corrosion-resistant valves will want full details on Powell Lubricated Plug Valves.

Available in Steel and Semi-Steel through distributors in principal cities. If none is located near you—or if you need help on valve problems—write direct to

PERFORMANCE PV VERIFIED

BRONZE, IRON, STEEL AND CORROSION-RESISTANT VALVES

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

The source of supply for all valve needs!

For more data on advertised products, use Readers' Service Cards, last page.

Split hairs? We split "spider webs" to give you better alloy steels

SHEFFIELD

ARMCO

High Strength

•

Shef-Ten

•

Forging Quality

•

Aircraft Quality

ALLOY STEELS

Accuracy is measured right down to the millionth part in the making of Sheffield Alloy Steel.

Here a technician measures with a densitometer the exact quantity of each element in a furnace sample. This unit provides a double check on other production control equipment which electronically analyzes each heat. Each alloying element, no matter how minute the quantity, must make the right contribution to obtain the physical and mechanical properties required for each particular end use.

Sheffield Alloy Steels in drill bits and collars penetrate the rock strata of the earth. In aircraft and guided missiles, they pierce the stratosphere.

As a manufacturer of just about any product using alloy steels, you'll find the metal tailored to your needs in Sheffield High Strength, Shef-Ten, Forging and Aircraft Grades. Get in touch with us.

Get your copy of "ALLOY STEELS"

If you're a manufacturer or otherwise engaged in industries served by alloy steels, write for your free copy of the Sheffield ALLOY STEELS book.

SHEFFIELD STEEL

DIVISION

ARMCO STEEL CORPORATION

SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

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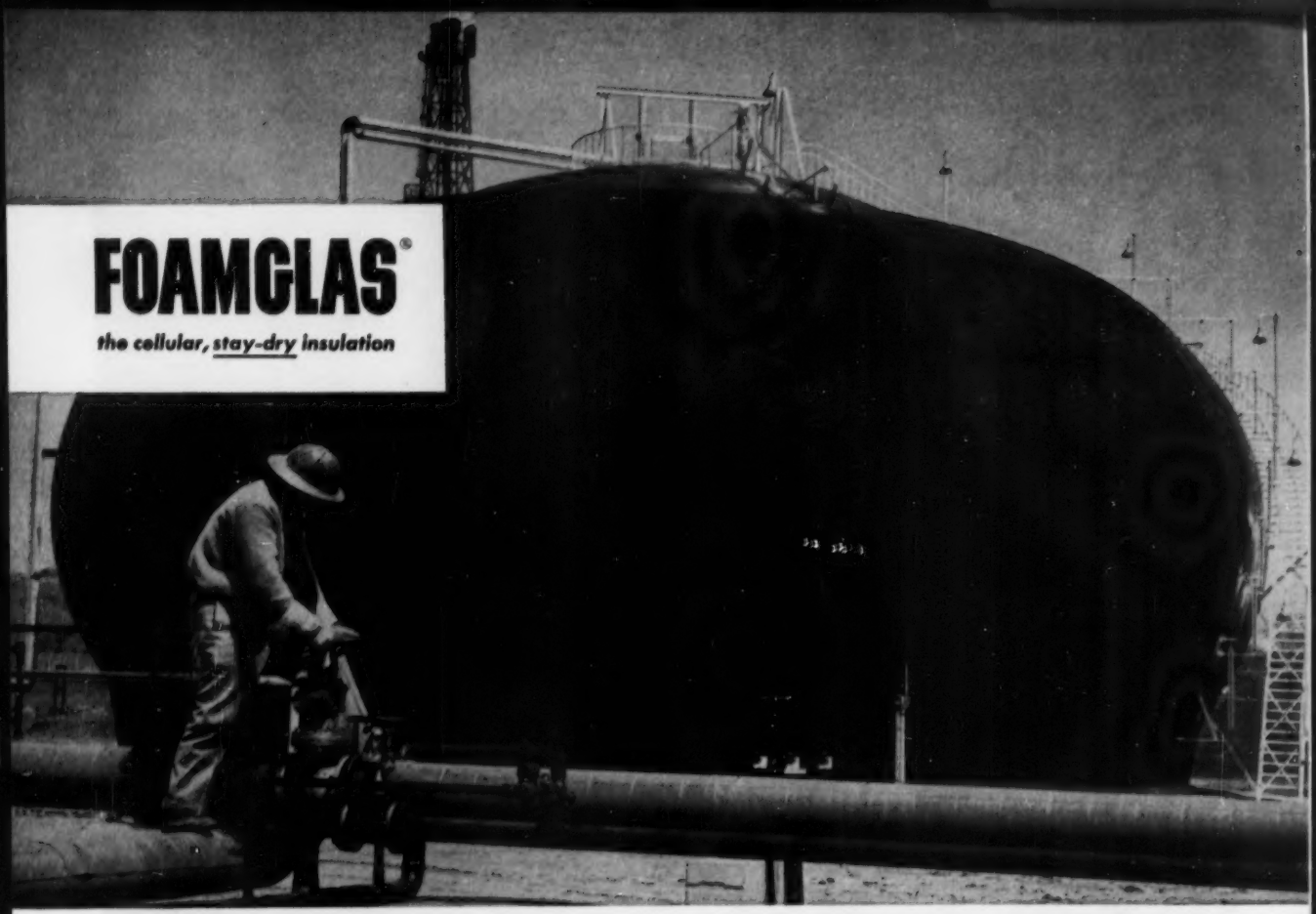


FOAMGLAS®

the cellular, stay-dry insulation

Gulf accurately controls the temperature of stored butane and cuts corrosion of tanks and piping . . . because FOAMGLAS insulation is moisture-proof. Excellent FOAMGLAS performance on earlier Gulf insulating jobs led to its use here, at their Cleves, Ohio, refinery. Similar installations are now underway at the company's Philadelphia refinery.

Gulf controls temperature and corrosion with moisture-proof FOAMGLAS insulating tanks and piping

Gulf Oil Corporation adds butane to Gulf gasoline for quick cold weather starting. And Gulf picked moisture-proof FOAMGLAS to insulate two 40,000 bbl butane storage tanks and fill lines at their Cleves, Ohio, refinery. Gulf had to get accurate butane temperature-pressure control and at the same time cut corrosion on tanks and lines.

Here's why they picked FOAMGLAS. This unique insulation is an inorganic, all-glass material composed of millions of sealed glass cells, each a tiny dead air insulating space. Since the cells are sealed, moisture cannot penetrate them to reduce or destroy insulating value. Gulf gets the constant insulating effectiveness needed to hold butane in a liquid state the year round at a temperature and pressure of 50°F and 10 psi.

Since FOAMGLAS is also a highly effective vapor barrier, it gives Gulf added corrosion protection. Moisture cannot penetrate the insulation which is adhered with mastic and thus cannot attack tank walls and piping.

Because it cannot burn, FOAMGLAS even helps to reduce fire hazards in handling such volatile fluids as butane. And neither acid atmospheres nor spillage can harm this inorganic material.

Whatever *your* tank, piping or equipment insulation problem, you'll solve it best with FOAMGLAS. Six simple "desk top tests," quickly performed on a FOAMGLAS sample in your own office, will convince you. Send for a sample and complete testing directions today. Address . . .

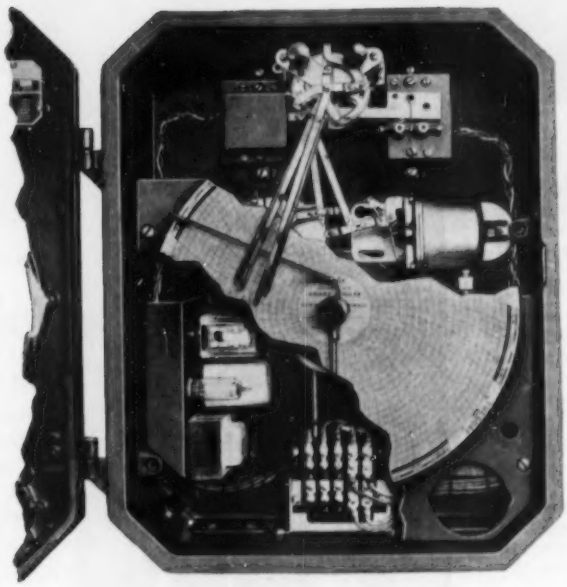
Pittsburgh Corning Corporation

Dept. Z-116, One Gateway Center
Pittsburgh 22, Pennsylvania
In Canada: 57 Bloor St. W., Toronto, Ontario

® Also manufacturers of PC Glass Blocks

At Gulf's refinery, Cleves, Ohio, FOAMGLAS blocks were installed on large butane storage tanks by impaling the blocks on steel studs welded to the tank surface. The ease of cutting and shaping FOAMGLAS enabled workers to do the job quickly and easily. Clips were then fastened to stud ends, and glass fabric, asphalt cutback and aluminum paint completed the installation. Insulation Contractor: Geo. V. Hamilton, Inc., McKees Rocks, Pa.

NEW ELECTRONIC CONTACT CONTROLLER BY *Taylor*



FEATURES

- Changing Resistor-Capacitor Can gives Single Point or Differential Control. Control point easily adjusted by set pointer.
- Fully adjustable, self-locking differential between high and low contacts. Safe contact voltage—never over 6 volts. Current in micro-amps.
- Self-wiping control contacts made of non-corrosive Monel. All other parts are hermetically sealed against corrosion.
- Electronic tube, Relay and R-C Can are plug-in units. Load Contacts on Relay are Single-pole double-throw.
- Attachments can be fitted to present 100 Series Taylor Instruments with no drilling.
- Internal wires and external connections numbered for easy servicing. Signal lights and vibration damping available.

HERE'S rugged, positive contact action for control mechanisms of the two-position action type—the "on-offs", "open-shuts" and "high-lows". This new Taylor Electronic Contact Controller embodies a completely new concept in contact mechanisms—it's designed for:

1. Accurate and dependable operation of electrical circuits.
2. On-off applications with small process lags, slow reaction rates, and small and infrequent load changes.
3. Use on nearly all types of measuring systems—temperature, pressure, liquid level, flow, humidity, speed, etc.
4. Indicating, recording and/or controlling purposes.

An extremely versatile instrument, the new Taylor Electronic Contact Controller can be used in many different places where pneumatic facilities aren't advisable or available. It's made also for use as a supplement to pneumatic control.

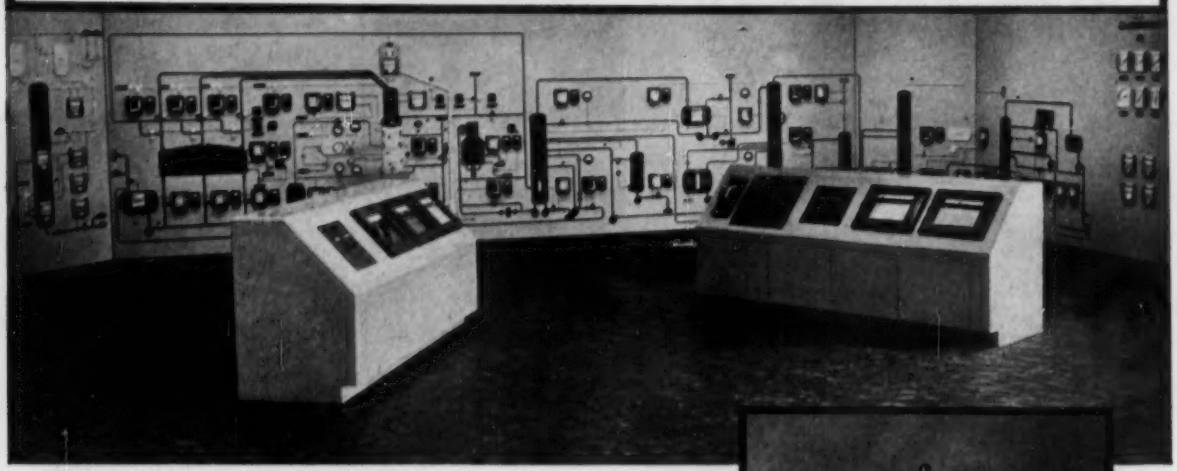
These standard forms emphasize the flexibility of the instrument: Two-Position Single Point Action (On-Off), Two Position Differential-Gap Action (On-Off with adjustable differential gap or neutral zone), and Three-Position Differential Gap Action (High-Medium-Low, differential adjustable).

For full details ask your Taylor Field Engineer or write for **Bulletin 98265.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

"American-Microsen" Electronic Control chosen by PETROFINA on proved performance



Photos courtesy The Lummus Company, New York, N. Y. and Canadian Petrofina Ltd., Montreal, P. Q.

This is the new refinery of Canadian Petrofina, Ltd., at Point aux Trembles, Quebec. Located here is the first Catalytic Cracking Unit in the Western Hemisphere to be operated by the "American-Microsen" Electronic Process Control System. It is the latest of hundreds of installations that have proved the reliability and practical advantages of "American-Microsen" control for refineries and chemical plants.

This Petrofina installation demanded long-distance transmission and difficult control applications, but start-up was completed ahead of schedule—to the benefit of refinery and contractor. *And the installed cost of the instruments was the same as for conventional controls.*

The long list of successful "American-Microsen" applications includes plant-scale operation of numerous critical petroleum and chemical processes. Conventional instruments could not control some of these processes, but they are handled easily by "American-Microsen" because of its speed of response, sensitivity and lag-free transmission. Many of these installations have been functioning well over a year, without maintenance problems, and with the enthusiastic approval of users.

You want better control and simplified servicing in automating your processes for higher product quality and greater economy. The "American-Microsen" Electronic Process Control System assures both—on new units and those now impossible to control satisfactorily. Invite one of our field sales engineers to help you determine the best equipment for your requirements without obligation, of course.

MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO-PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

Richard C. Waldron, Okonite's Manager of Engineering, explains:

How to tell right from wrong in plastic control cables

With hundreds of compounds to choose from, it's easy to make an incorrect choice when selecting thermoplastic control cable for refinery, natural gas and petrochemical use. The wrong choice can be extremely costly.

Specific Okonite plastic cable insulation and sheath compounds make your selection easier

Okonite has recently introduced several Okoseal (polyvinyl chloride) and Okolene (polyethylene) insulations and sheaths compounded to Okonite's own formulas. From these you can select the exact combination of insulation and sheath for your specific environment: salt water, petroleum oils, paraffinic hydrocarbons, alcohols, mineral acids, fixed alkalies, ketones, esters, halogenated hydrocarbons.

Make your selection from these new bulletins

Especially compiled for the petroleum and petrochemical industries, the following bulletins give complete technical information, including dimensions, on Okonite plastic cables for power, control, machine tools, lighting circuits, motor leads, switchboards, communications and cathodic protection.

THE OKONITE COMPANY, Passaic, N. J.
Kindly send me the free bulletins checked below.

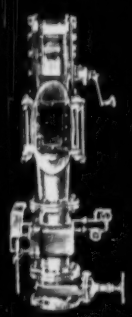
- ☐ **BULLETIN 2120**—Insulated Power and Control Cable—600 Volts (Okoseal 100)
- ☐ **BULLETIN 2121**—Machine Tool and Switchboard Wire—600 Volts (Okoseal 200)
- ☐ **BULLETIN 2122**—High Ambient Petroleum and Chemical Resistant Wire—600 Volts (Okoseal 300)
- ☐ **BULLETIN 2123**—Oil and Gas Resistant Wire—600 Volts (Okoseal-Nylon, Type OGR)
- ☐ **BULLETIN 2124**—Multi-Conductor Control Cable—600 Volts (Okoseal 100)
- ☐ **BULLETIN 2125**—Insulated Power and Control Cable—0-5000 Volts (Okolene 400)
- ☐ **BULLETIN 2126**—Multi-Conductor Control Cable—600 and 1000 Volts (Okolene 400)
- ☐ **BULLETIN 2127**—Cathodic Protection Cable (Okolene 400)
- ☐ **BULLETIN 2128**—Relative Environmental Performance Data for Plastic Insulations and Sheaths

NAME..... TITLE.....
COMPANY.....
ADDRESS.....
CITY..... STATE.....

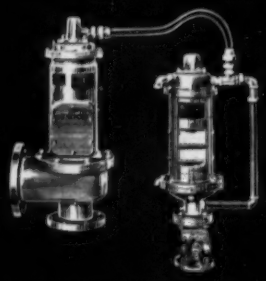
where there's electrical power... there's **OKONITE CABLE**

4324

Fittings for Spheres too!

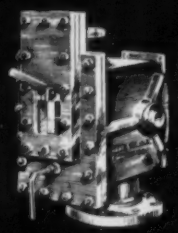


Semi-Automatic Tank Gauge and Sampling Lock, Fig. ST-9320 "DLB." Can be used for sampling and temperature thiefing. It is mounted here on S&J's Quick Opening Gate Valve, Fig. TT-135 which can be opened or closed with only half the number of turns required by other valves.



Pilot Operated Safety Relief Valve, Fig. ST-2500. Designed to protect tanks from excessive internal pressure. One pilot valve can serve one, two, or more main valves to meet high venting requirements. Main valve pallet is seated under pressure to moment of venting. This valve requires no great excess pressure for full venting capacity.

Vacuum Breather Valve, Fig. ST-1926. Designed to meet the unusual vacuum breathing requirements of pressure storage tanks, and to withstand high internal pressures when not in operation under a vacuum. This valve is automatically self draining, and utilizes a hinge type pallet.



High Pressure Automatic Tank Gauge, Fig. ST-400, will consistently and accurately measure product depths. Features new Safety Closure to protect extra thick Safety Glass. Gauge greatly reduces time required to measure tank contents accurately, because it can be installed at eye level height.

Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
342 Madison Ave.

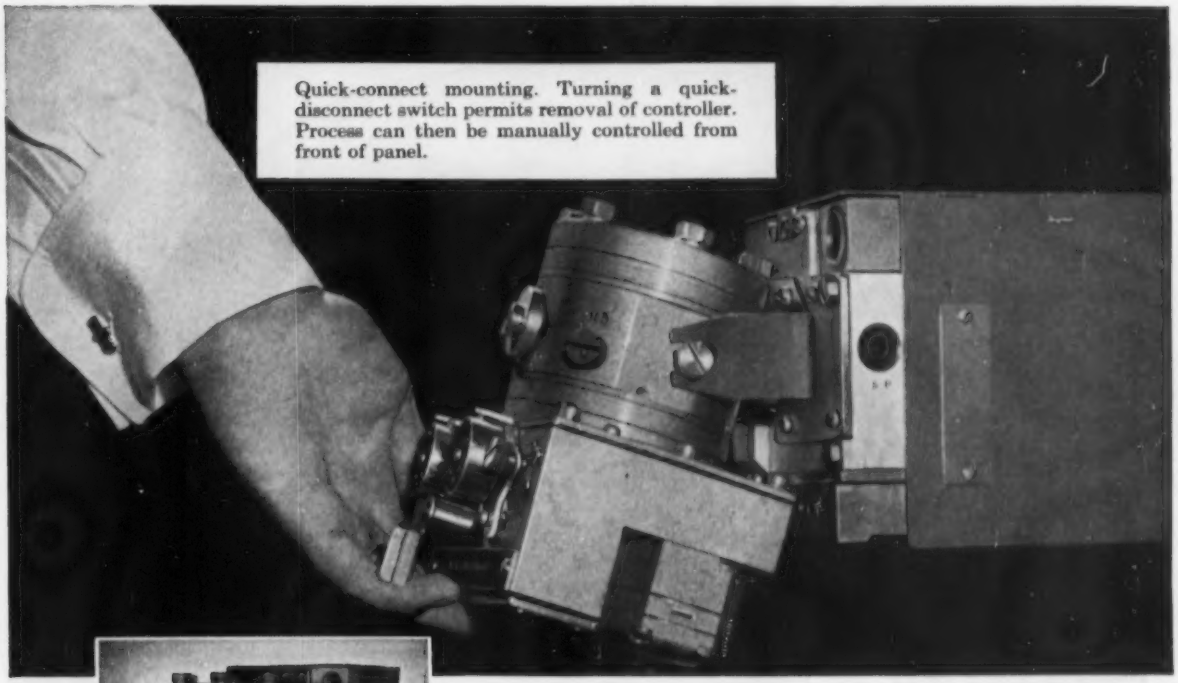
TULSA
Thompson Bldg.

CHICAGO
10409 S. Western Ave.

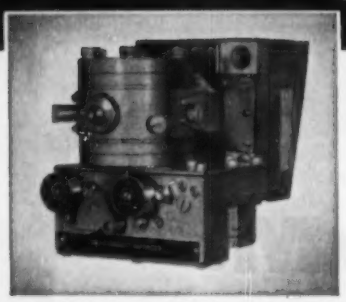
HOUSTON
M. & M. Bldg.

LOS ANGELES
6399 Wilshire Blvd.

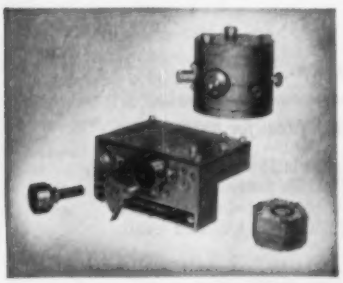
REPRESENTATIVES:
SEATTLE: Nebar Supply Company, 3000 Western Avenue
MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
TORONTO: Lytle Engineering Specialties, Ltd., 69 Eglinton East
VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
CALGARY: P. D. McLaren & Son, Ltd., 510 - 9th Ave. W.
MEXICO, D.F.: Dalma Comercial, S. A.
CARACAS: Sinclair Spence, C.A., Edificio Galipan
BUENOS AIRES: Jorge G. Butler, Reconquista 558
ENGLAND: Whessoe, Ltd., Sales: 25 Victoria St., London S. W. 1
Whessoe, Ltd., Works: Darlington, County Durham



Quick-connect mounting. Turning a quick-disconnect switch permits removal of controller. Process can then be manually controlled from front of panel.



All adjustments, filters and restrictions are accessible on the face of the controller.



Unitized construction permits easy replacement of all major components.

control any process variable with one **TEL-O-SET** controller

THERE'S just one model of the adjustable band *Tel-O-Set* controller . . . and you can use it to control flow, temperature, pressure, or any other variable. It has the speed of response, high sensitivity, and on-the-job versatility to simplify many control problems.

If necessary, you can remove one *Tel-O-Set* controller and replace it with another in a few seconds. Downtime is minimized. Maintenance is simplified. Your spare parts inventory is reduced. And you can easily change processing techniques without buying additional instruments.

Reset range selection—Change the reset range to suit any process variable—just by repositioning a single screw.

Compensated rate action—You can easily add rate action to the basic model . . . before the deviation section . . . so that overshoot on start-up is held to an absolute minimum.

Unitized construction—Each component of the *Tel-O-Set* controller can be replaced with an identical precalibrated component.

Quick-connect mounting—Mount the *Tel-O-Set* controller on the back of the recorder, on the valve, or anywhere between.

Made by the world's largest instrument manufacturer, *Tel-O-Set* controllers have demonstrated outstanding performance in countless applications over the years. Call your nearby Honeywell sales engineer for a discussion of how you can profit by their many advantages. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Aves., Phila. 44, Pa.—in Canada, Toronto 17, Ont.

Write for Literature

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

NEW

from K&M best in asbestos®

KaytherM®

PIPE INSULATION

Highly efficient from 250° F. to 1350° F.

***LIGHT IN WEIGHT** for easiest handling.*

***EXTRA STRONG** to allow for job pre-fabrication.*

***DIMENSIONAL STABILITY** helps prevent expansion-caused leaks.*

***INSOLUBLE IN WATER, CHEMICALLY STABLE.** Ideal for outdoor use.*

Years of research by Keasbey & Mattison, insulation pioneers, have resulted in a new, highly efficient, pipe insulation made of lime and silica (hydrous calcium silicate) with asbestos fibers added for strength. It's called KaytherM and it's strong, light in weight, and easily handled and cut.

KaytherM Pipe Insulation comes in simplified thicknesses and in pipe sizes up to 33" in diameter. KaytherM is also available in block form.

AVERAGE PHYSICAL CHARACTERISTICS—(Bone Dry Basis)

Temperature limit	1350° F.
Density, lbs./cu. ft.	11.5
Modulus of Rupture, lbs./sq. in.	65
"K" Factor at mean temperatures	100° F.—0.330
	400° F.—0.465
	800° F.—0.650

Write to us for full descriptive literature.

KEASBEY & MATTISON COMPANY • AMBLER • PENNSYLVANIA

ENGINEERS WANTED—Career opportunities open for men qualified in product development, machine design, automation, plant management, plant engineering and applied research. Write to Director of Engineering, Keasbey & Mattison Company, Ambler 4, Pa.

Now...a New advance in...

Gauge Safety!

Another step ahead in Marsh Gauges: the new Marsh "Safecase". Down to the final detail this gauge is developed for those applications where an unexpected surge of heavy, explosive over-pressure can occur.

In the "Safecase" a solid metal barrier protects the entire face. But, still more important, the *entire back* of the gauge is a thin, ductile plate, designed to open out when subjected to abnormal pressure. Back plate is held firmly to the case by two holding screws and cannot be dislodged by a pressure blowout.

In exhaustive tests it has never been possible to shatter the crystal or create any other dangerous condition in a "Safecase" gauge with its safety-release back. The accompanying illustration shows the result of one of a series of tests in which blank cartridges were fired in the back of the case without even breaking the crystal. Think what that means in safety to operating men!

Yes, an important development . . . but merely the kind you would expect from the manufacturer who originated the "Connoweld" tube, the "Marshalloy" case, the Mastergauge movement and practically all of the major advancements in pressure gauges. Ask for up-to-the-minute information.

Pressure of explosive force merely opens out safety back

Instead of depending on blow-out plugs, entire back of Safecase Gauge is designed to yield to over-pressure. Photo at left shows actual result of firing cartridge within back of case. Safety-release back exhausted pressure. Front remained intact.

MARSH INSTRUMENT CO.
Sales affiliate of Jas/ P. Marsh Corp.
Dept. R., Skokie, Illinois
HOUSTON BRANCH PLANT:
1121 Rothwell St., Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd.,
8407 103rd St., Edmonton, Alberta, Canada

"THE STANDARD OF ACCURACY"

MARSH GAUGES

For more data on advertised products, use Readers' Service Cards, last page.

customer reports prove

Big Savings with . . .

OCECO V-130 Conservation Regulators

Exclusive construction assures tight leak-proof closure fully up to operating setting — quick opening — and extremely high flows even at low pressures.

Oceco V-130 Conservation Regulators provide **greater flow capacity,** size for size, and pressure for pressure, **specially at low pressures** than **ever available before.** Our exclusive construction prevents vapors from escaping at less than set operating pressures. Positive flexing action of the membrane, held under tension, peels off and breaks away any icy formations, preventing freeze-ups. These valves bring never before secured **all weather** economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. **Write for Bulletin No. 522. It gives full details!**

PRESSURE BALANCED CONSTRUCTION.

Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting— and positive flexing action that peels away icy formations preventing freeze-ups.

EXCLUSIVE OCECO FEATURE SAVES YOUR VAPOR DOLLARS!

THE JOHNSTON & JENNINGS CO.

4700 West Division Street • Chicago 51, Illinois

***Division of* PETTIBONE MULLIKEN CORPORATION**

You'll never have to nurse this O_2 Analyzer

What are your most serious complaints about O_2 analyzers? Cumbersome? Slow? Unstable? Hard to service on the job?

You won't find these potential trouble-sources in our new Unitized O_2 Gas Analyzer. They've been literally "designed out" by L&N engineers with experience totaling millions of man-hours in industrial gas analysis.

The Unitized O_2 Analyzer is reduced to the essentials consistent with highly efficient O_2 measurement and control. The entire analysis is made within the 2-component team of O_2 Analyzer Assembly and Speedomax® recorder, eliminating unwieldy auxiliary components such as sample conditioners. Due to its direct magnetic operation, the equipment employs neither auxiliary gas supplies, chemical reactions, nor combustion. Sample and calibration controls are accessible externally, without disturbing the measuring system.

We've introduced sampling innovations, too. The Analyzer gets a sample not only cleaned but purified. A typical sampling lag is 1 sec per 45 ft of ¼" tubing, up to several hundred feet.

The Unitized O_2 Analyzer can help to streamline O_2-dependent processes. For pertinent details of this O_2 monitor, write to 1923 Stenton Ave., Phila. 44, Pa., for Folder ND46-91(5).

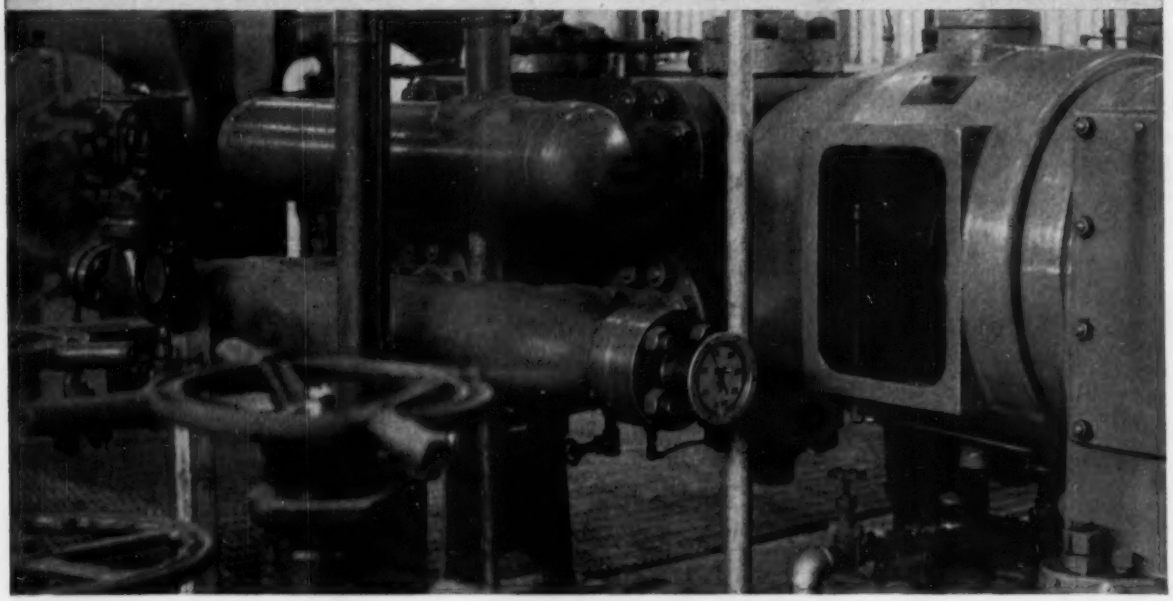
PERFORMANCE

Range	*0 to 5% O_2, 0 to 10% O_2, or higher in flue gas or N_2 as specified.*
Accuracy	*0.15% O_2*
Sensitivity	*Better than ±0.05% O_2*
Stability	*Better than ±0.15% O_2*
Response	*4 sec for initial response; 40 sec for 90% response.*

LEEDS [N] **NORTHRUP**
instruments — *automatic controls • furnaces*

For more data on advertised products, use Readers' Service Cards, last page.

VIBRATION



Vibration of refinery compressor proves unshakable accuracy of RMC thermometer

The RMC Thermometer shown in the photograph is constantly subjected to extreme vibration from the two-stage Synthesis Gas Compressor on which it is installed. This powerful equipment is used to compress a mixture of H_2 and N_2 from 400 to 3500 pounds—at the Philadelphia Synthetic Ammonia Plant of The Atlantic Refining Company.

This particular job required a special thermometer that could withstand the constant and terrific vibration, and at the same time provide and maintain precise, accurate readings. Rochester Manufacturing Company promptly came up with the answer—a silicone-dampened, bimetallic, angle-form RMC thermometer. And this is but one example of how RMC engineering skill provides instruments that meet the most demanding and exacting requirements.

Look to RMC for Full-Line Instrumentation

DIAL THERMOMETERS

Illustrated here is a 6" dial thermometer with hermetically sealed dial chamber, external recalibration—built for heavy duty service. What are your thermometer requirements?

PRESSURE SWITCHES

This RMC Pressure Switch will stand heavy pulsating pressures, has close on-off differentials, maintains consistent cut-in, cut-out settings. What are your pressure switch problems?

TELL US YOUR REQUIREMENTS FOR DIRECT MOUNTING AND REMOTE INDICATING INSTRUMENTS, AND LET RMC ENGINEERING SKILL PROVIDE THE ANSWERS!

REPRESENTATIVES IN ALL PRINCIPAL CITIES

RMC

"You Can Rely On Rochester"

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

© 1956 Rochester Manufacturing Co., Inc.

For more data on advertised products, use Readers' Service Cards, last page.

how much does heater downtime cost?

A 36,000 B/D petroleum refining unit using a 100 million Btu heater upgrades the value of its crude charge roughly $25,000 per stream day. If the heater comes down for any reason only 10 days a year, a loss of a quarter million dollars is chalked up. A gain of 30 operating days in the year can mean a realization of 10% on capital investment which, in a multi-million dollar plant, is a considerable sum.

Downtime is expensive. The purchaser of a heater must as a result look beyond his initial cost to the long pull. For the long pull, Lummus oil heaters have consistently exhibited great durability while operating efficiently and with an absolute minimum of days lost to maintenance work.

The major refiners prefer Lummus heaters for this reason. In the last 25 years, the dollar value of Lummus furnaces purchased has exceeded that of any other company in the world. So—when you consider a new refinery or a new unit—assure good operation and maximum profit throughout the life of your plant.

Consult with us on design, engineering and construction of your heater installation.

The Lummus Company, Oil Heater Division, 385 Madison Avenue, New York 17, N. Y. Branch offices in Chicago, Houston, Montreal, London, Paris, The Hague, Caracas.

LUMMUS

OIL HEATER DIVISION

For more data on advertised products, use Readers' Service Cards, last page.

One man in this midget fire truck puts out the fire. Rockwood equipment makes it possible!

"Mighty Mite" puts out fire in 45 seconds

"Mighty Mite" is a swift fire fighter!

It was just a test, but the fire was real. Fuel in a pit under the tank car was set on fire. Fuel poured on top of the car from pipes was also ignited. The blaze was given a minute's start.

"Mighty Mite", loaded with Rockwood fire fighting equipment, went into action. The blaze was choked off in 45 seconds by Rockwood WaterFOG from Rockwood's Remote Manual Control Turret!

Rockwood equipment makes the small truck a big fire fighter. The Turret Nozzle does many jobs—discharges solid water stream, WaterFOG, FogFOAM, solid FOAM stream, "Wet" solid water stream, and "Wet" WaterFOG!

For complete details on this powerful Rockwood equipment send coupon below.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities

"Mighty Mite's" equipment includes: 4 stage centrifugal pump, 200-gallon booster tank, Rockwood Dual Suction Proportioning System for FOAM and "Wet", Rockwood Remote Manual Control Turret controlled from within the cab, Rockwood Ground Sweep Nozzles, Rockwood Remote Control Ball Valves, 2 hose reels with 200 feet of high pressure hose with new Rockwood High Pressure Handline Nozzle on each reel.

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
1600 Harlow Street
Worcester 5, Mass.

Please send me your illustrated booklet on Rockwood fire fighting products.

Name .....

Title .....

Company .....

Street ..... *City* .....

Zone ..... *State* .....

For more data on advertised products, use Readers' Service Cards, last page.

STAINLESS STEEL*

TO MARK PROGRESS

FITTINGS
1/8"
THROUGH
36"

LADISH

...FOR COMPLETE SERVICE
IN *Controlled Quality* FITTINGS

When you need service in stainless and alloy fittings... regardless of material specification, size, type, or wall thickness... you can depend on the Ladish Controlled Quality line and the services of your Ladish Stainless Distributor for complete satisfaction.

IPS WELDING FITTINGS		½" through 36" From Sch. 5S to wall thicknesses through 4"
O.D. TUBING FITTINGS		1" through 36" From .049" wall to .250" wall
MSS AND ASA FLANGES		1" through 24" 150 lb. through 2500 lb.
150 LB. SCREWED FITTINGS		⅛" through 4"
FORGED SCREWED AND SOCKET FITTINGS, UNIONS		⅛" through 4" 2000 lb. through 6000 lb.

THE COMPLETE *Controlled Quality* FITTINGS LINE

LADISH CO.

CUDAHY, WISCONSIN
MILWAUKEE SUBURB

District Offices: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland
Chicago • St. Paul • St. Louis • Atlanta • Houston • Odessa • Tulsa • Denver
Los Angeles • San Francisco • Seattle • Havana • Mexico City • Brantford, Ont.

*Also furnished in any forgeable material specification including...
Titanium, Aluminum, Copper, Nickel, and Chromium Base Alloys.

A DAY

in the lives of a quarter of a million people

More than 240,000 people keep Cities Service, one of the world's largest oil companies, operating at full steam . . . 240,000 people who locate, produce, refine, improve, market and invest in the petroleum that constitutes any oil company's lifeblood.

A winning team? Judge for yourself: Today, Cities Service is pushing forward in ever longer strides, with new refining facilities and techniques, new oil discoveries, new pipelines and tankers, new dealers, and new and improved petroleum products, unsurpassed in quality.

Moreover, the very fact that this surging activity exists, serves to assure further expansion . . . for healthy growth stimulates still more growth.

And significantly, this growth is more than the sign of a healthy company . . . it's living proof of a healthy country. For it again demonstrates the rich harvest of a system in which government, industry, and all citizens share an interest and an obligation toward each other.

CITIES SERVICE

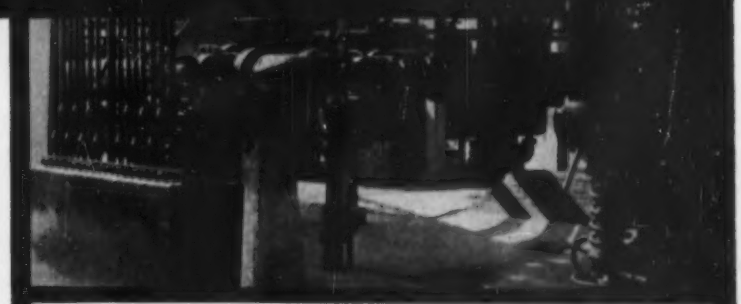
Progress through Service

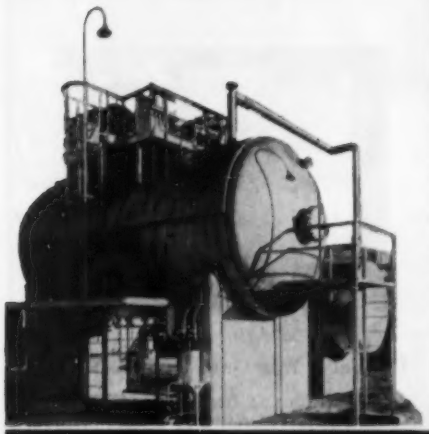
For more data on advertised products, use Readers' Service Cards, last page.

ANY WAY
YOU LOOK
AT IT...

PETRECO

IS YOUR
BEST BUY
IN DESALTING





Petreco Electric Desalting has been used by more refiners, for more years, than any other desalting process. Petreco desalters have successfully treated every type of crude charged to them in refineries all over the world. They are delivering zero to very low residual salt content charging crudes to refineries in the tropics as well as in the icy temperatures of Canada. Petreco service engineers, located in every area where Petreco units operate, constitute the largest trained group of desalting experts in the world. Petreco offers a selection of equipment suitable for desalting any volume of oil, large or small. There is a choice of purchase arrangements.

SPECIALIZED ELECTRIC PETROLEUM TREATING

DESALTING • DEHYDRATING • CAUSTIC WASHING • ACID CONTACTING • DOCTOR TREATING • SWEETENING • NAPHTHENIC ACID REMOVAL • SEDIMENT REMOVAL

D56-5

For complete information, write or call —

PETRECO

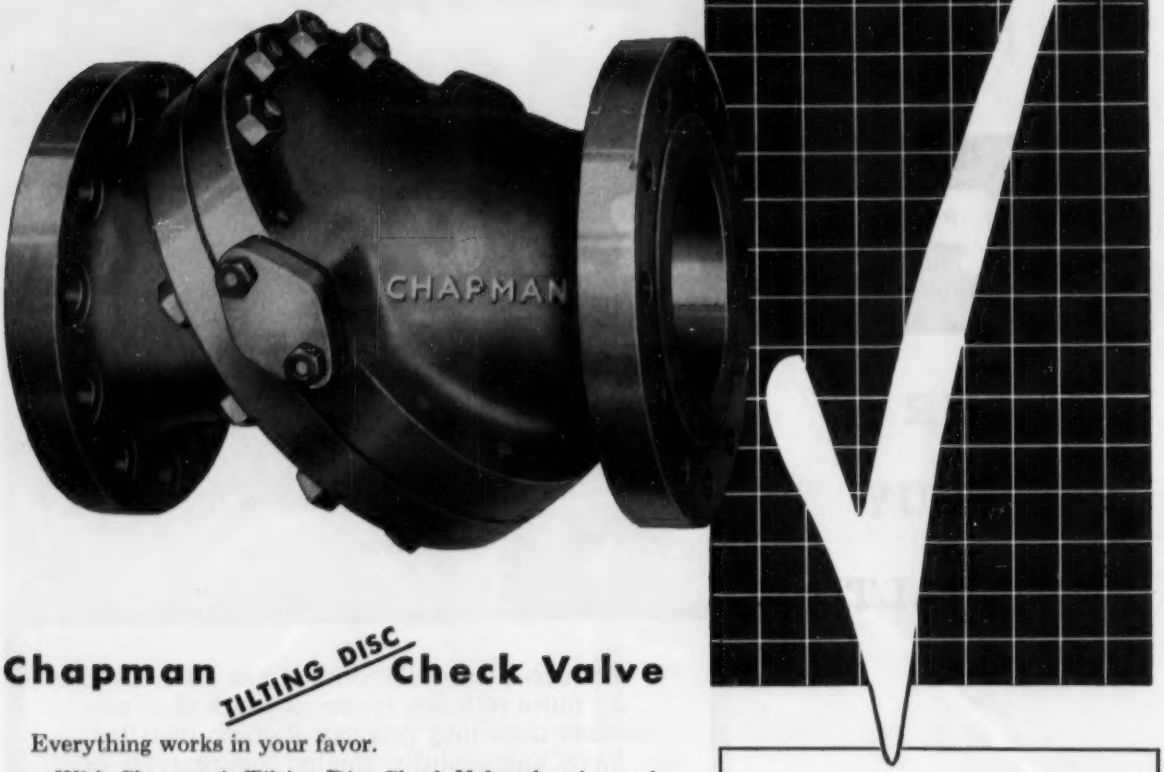
A DIVISION OF PETROLITE CORPORATION

3202 So. Wayside Drive, Houston 1, Texas

1390 E. Burnett Street, Long Beach 7, California

For more data on advertised products, use Readers' Service Cards, last page.

Check This Check Valve
and keep your troubles in check



Chapman TILTING DISC Check Valve

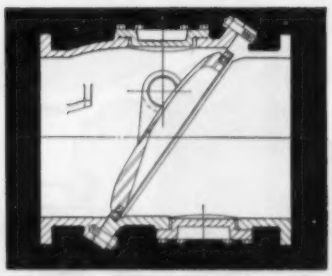
Everything works in your favor.

With Chapman's Tilting Disc Check Valve there's no vibration, no fluttering, no noise. There's no slamming, with usual piping arrangements, no banging to cause damage to system or valve. There's no grinding, scraping or wearing to either the disc or seat.

All of this means less headaches to you . . . both physical and financial headaches. The smooth, sure, quiet action means less, much less, maintenance over the longest period under toughest operating conditions.

Chapman Tilting Disc Check Valves with money-saving advantages like these are available in iron and steel, with standard end to end, for handling fluids or gases under a wide range of pressures. They're listed and shown in our Catalog 30-A. Send for it and check the valves you need for replacement or new piping systems, right now.

The CHAPMAN Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS



The Valve That Goes with the Flow

Here's the idea in back of it all. When the flow is on, "airfoil" disc is held firmly against stops in the body. When the flow drops, disc balances itself quietly on whatever flow there is. When the flow stops, disc drops quickly and tightly on special bevel seat. It's as simple as that. It's as sound as that. And valve men will be pleased when they see that enough room is given around disc to cut down flow resistance.

For more data on advertised products, use Readers' Service Cards, last page.

IN PETROLEUM ... from wells to wings!

BASIC CHEMICALS ... from GENERAL CHEMICAL

At practically every stage of petroleum production and processing, you will find need for basic chemicals from General Chemical . . . a supplier you can count on for prompt delivery of these key process materials, that meet your exact requirements:

ALKYLATION
Anhydrous Hydrofluoric Acid
Sulfuric Acid

POLYMERIZATION
Fluosulfonic Acid $HO:SO_2F$
Boron Trifluoride
Sulfuric Acid

SULFONATION
Sulfuric Acid
Sulfan® (Stabilized Sulfuric Anhydride)
Oleum

ISOMERIZATION
Hydrochloric (Muriatic) Acid

DETERGENTS, CLEANERS & BUILDERS
Sodium Metasilicate
Disodium Phosphate
Sodium Sulfate, Anhydrous
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

ACIDIZING
Hydrochloric (Muriatic) Acid
Hydrofluoric Acid
Sodium Bifluoride

MUD CONDITIONING
Sodium Silicate
Disodium Phosphate
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

GREASE MAKING
Aluminum Sulfate

ACID TREATING
Sulfuric Acid
Sodium Silicate

Other Heavy Chemicals, catalysts, addition agents, inhibitors and special "tailor-made" chemicals.

Baker & Adamson® Laboratory Reagents

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte Chicago • Cleveland • Denver • Detroit • Greenville (Miss.) • Houston • Jacksonville Kalamazoo • Los Angeles • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh Providence • San Francisco • Seattle • St. Louis • Yakima (Wash.)

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver

GC Allied Chemical

Basic Chemicals for American Industry

For more data on advertised products, use Readers' Service Cards, last page.

HOWE-BAKER DESALTING AND TREATING

insure bigger profits and better products!

ELECTRICAL DESALTING

It is a proven fact that electrical desalting makes money for the refiner. Economic studies show that payouts will vary from a low of 60% per year to a high of 250%.

A Howe-Baker installation will give you minimum gains of:

- 4.6c/bbl. from increased capacity
- 1.1c/bbl. from reduced maintenance
- 1.6c/bbl. from catalytic and thermal cracking operations
- 0.6c/bbl. from reduced corrosion
- 0.2c/bbl. from increased tank capacity

- 8.1c/bbl. Total Credit

At your request, a Howe-Baker representative will visit your plant to discuss your desalting problem with you. In the meantime, send for our electrical desalting brochure.

Over two million barrels of crude oil per day are being treated by Howe-Baker electrostatic units.

DISTILLATE TREATING

Use Howe-Baker's pilot units to find the answers to your distillate treating problems. You'll see how electrical precipitation antiquates all other methods of treating distillates.

Fully automatic, Howe-Baker's process insures a *high* and *consistent* product quality. High because electrical precipitation eliminates carry-over of the discontinuous phase, whether it be caustic, water or acid. Consistent because the automatic process assures uniformity.

Howe-Baker equipment saves money by reducing chemical consumption, pollution, maintenance costs and storage tank requirements; eliminating drying systems; and improving product quality. These savings are making bigger profits right now for many major oil companies.

Send for our brochure which describes the process in detail. Then use our pilot unit to test your feed stock, at no cost to you. The test will prove the worth of a Howe-Baker unit for your company.

A Howe-Baker Electrical Precipitation Unit may be installed in your existing vessel.

HOWE BAKER CORP.

Bank of the Southwest Bldg. • Houston 2, Texas

I'd like to have more information about how your processes can increase our profits. Please send me your

- ☐ distillate treating brochure
- ☐ electrical desalting brochure
- ☐ both

Name_____

Company_____

Street or P. O. Box Address_____

City_____ State_____ Country_____

Howe-Baker Corporation • Bank of the Southwest Bldg. • Houston 2, Texas

World's Largest Acetylene Plant

from Natural Gas

(BASF Acetylene Process)

ENGINEERED AND BUILT BY

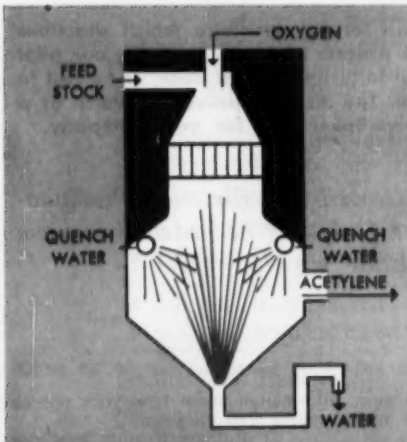
CHEMICO

The BASF* **Acetylene Plant** of American Cyanamid Company at Avondale, Louisiana, engineered and built by CHEMICO, is now being increased in capacity, making it the WORLD'S LARGEST ACETYLENE PLANT OF ITS TYPE.

By 1957, all the plants engineered and built by CHEMICO for the production of acetylene from natural gas will have a total capacity of 150,000,000 pounds per year.

Important features of the BASF process are listed below, and reprints of article describing this process are available upon request.

* Badische Anilin & Soda Fabrik, AG, West Germany, holder of the basic acetylene process for which CHEMICO has exclusive rights in all North American Countries.



Features of the BASF Acetylene Process

Produces commercially pure acetylene, meeting specifications for the manufacture of acetylene derivative products such as Acrylonitrile, Vinyl Chloride, Methylstyrene, etc.

Permits the use of a variety of feed stocks such as Methane, Ethane, Propane and other petroleum gases.

Produces off-gas suitable for Ammonia and Methanol synthesis.

Permits integrated production of Acetylene and Ammonia to meet changing market demand.

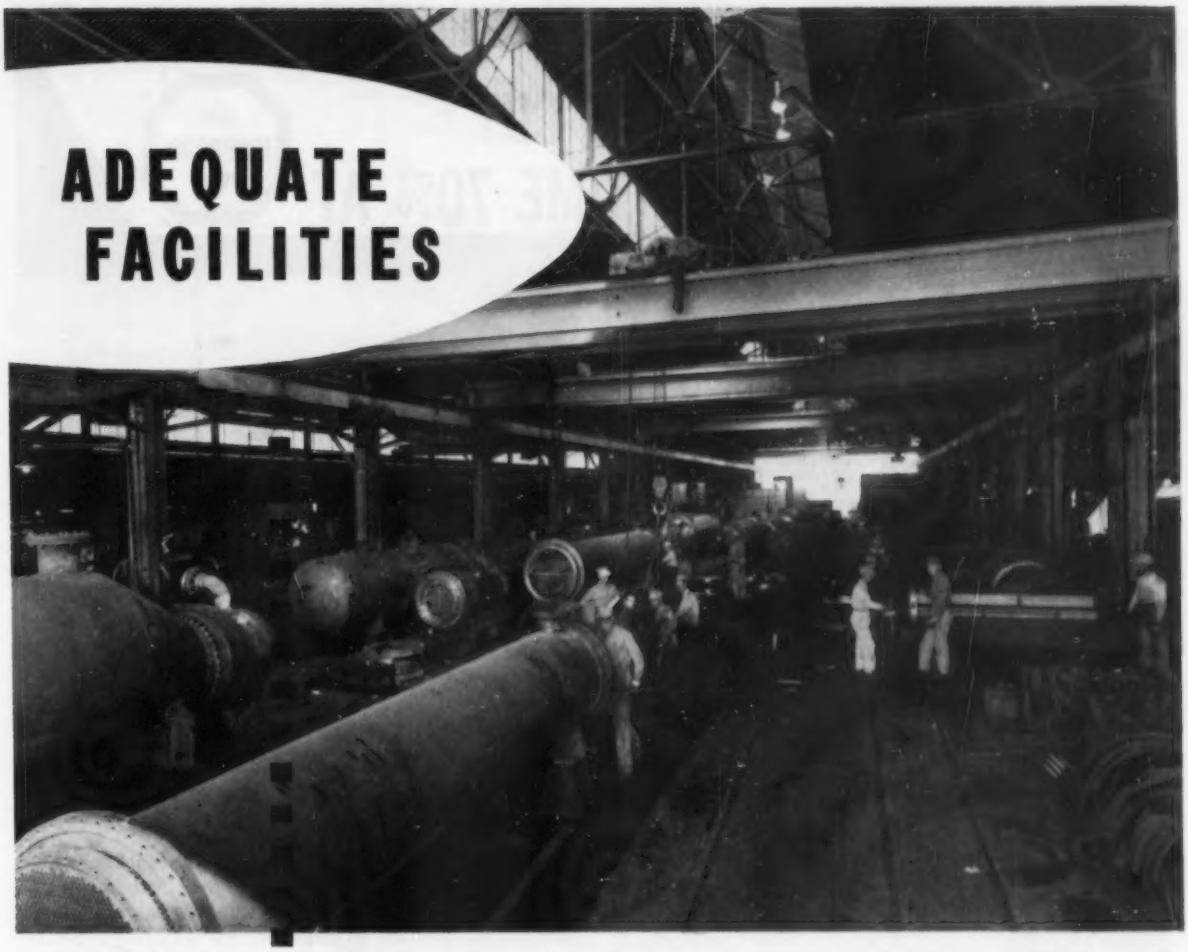
CHEMICAL CONSTRUCTION CORPORATION

A SUBSIDIARY OF ELECTRIC BOND AND SHARE COMPANY

525 WEST 43RD STREET, NEW YORK 36, NEW YORK

CC319

ADEQUATE FACILITIES



EFCO's Four Point Program Provides:

- service-proved engineering design
- guaranteed job ratings
- complete fabricating facilities
- technical service before, during and after installation

One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

ASK OUR GULF COAST CUSTOMERS — THEY KNOW US WELL

Write for General Catalog

EFCO HEAT TRANSFER EQUIPMENT

Engineers and Fabricators, Inc.

P. O. BOX 7395 **HOUSTON 8, TEXAS**

EFCO

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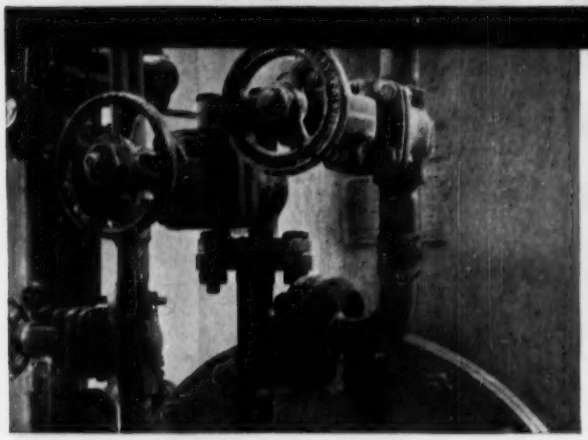
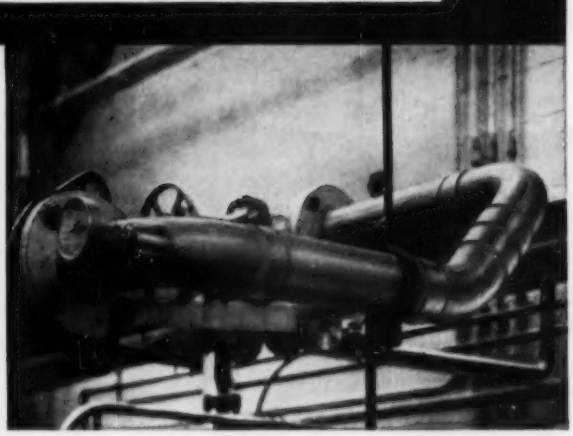
Speedline®

FITTINGS CUT INSTALLATION TIME 70% AT KOPPERS





70% Reduction in Installation Time

Plus Savings in Material Costs on Stainless Steel Process Lines

Manufacture of polyethylene demands a completely leak-proof, non-corrosive process piping system. Koppers Company knew that Schedule 40 stainless steel pipe with conventional threaded fittings could solve corrosion problems, but wanted to avoid costly leakage at joints in a new installation. "Back welding" to eliminate leakage would require additional installation time and labor—and result, at best, in a cumbersome, unsightly job.

So Koppers chose SPEEDLINE Fittings. Extensive tests proved to them that 100% protection against leakage could be accomplished with the use of SPEEDLINE Fittings and light wall pipe. Not only was leakage avoided, but installation time was reduced by 70%. In addition, material costs were considerably less than they would have been for pipe wall heavy enough to allow for loss of wall thickness at the threads.

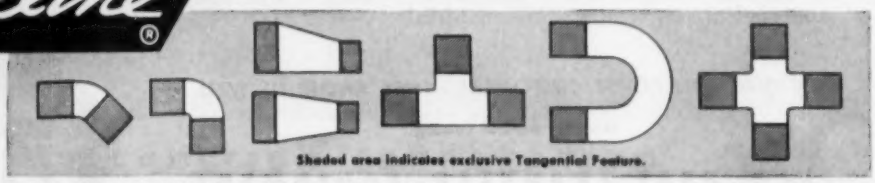
SPEEDLINE's exclusive "tangential feature" provides the engineering advantages that simplify process pipeline assembly. The extra straight section on all formed fittings allows maximum clearance for welding or flanging assembly. The "tangential feature" also provides for direct attachment of SPEEDLINE Insert Flanges by simple expanding operation—allowing use of flanged connections wherever required. SPEEDLINE Aligning Connectors permit "in place" pre-assembly of pipeline prior to welding.

Once you investigate the use of SPEEDLINE Stainless Steel Fittings and low cost, light wall pipe for your particular process lines, you'll discover bonus advantages right down the line. An illustrated brochure describes in detail how a SPEEDLINE system can determine efficient process operations at your plant. Write for a copy without obligation . . . or contact the SPEEDLINE distributor nearest you.

Speedline®

SPEEDLINE DISTRIBUTORS ARE LOCATED IN PRINCIPAL CITIES FROM COAST TO COAST

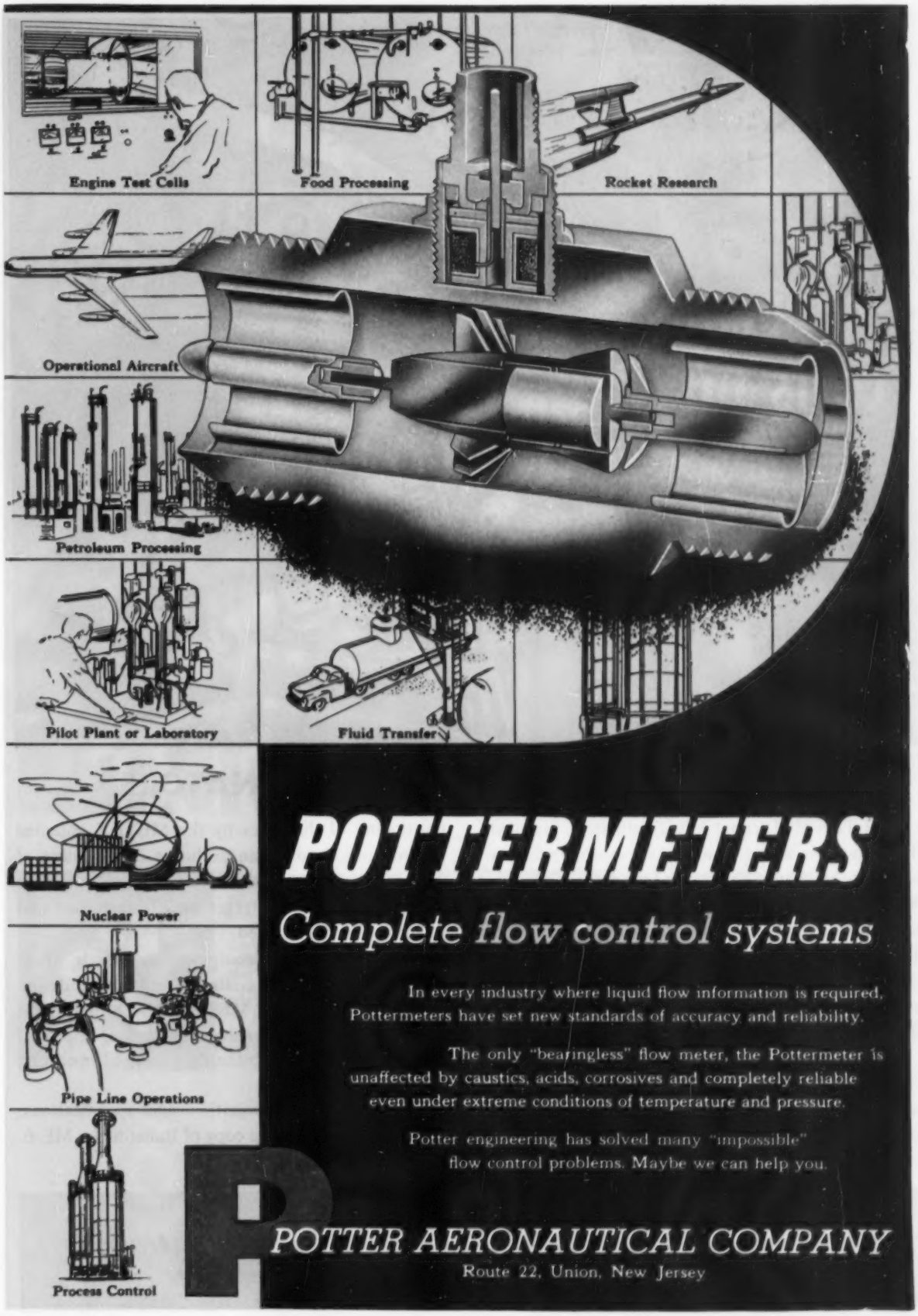
Write for a copy of "Speedline Fittings"... without obligation



Shaded area indicates exclusive Tangential Feature.

Also see SPEEDLINE STAINLESS STEEL FITTINGS—the newest thing in pipeline economy

Manufactured by HORACE T. POTTS COMPANY • 566 E. Erie Avenue • Phila. 34, Penna.



POTTERMETERS

Complete flow control systems

In every industry where liquid flow information is required, Pottermeters have set new standards of accuracy and reliability.

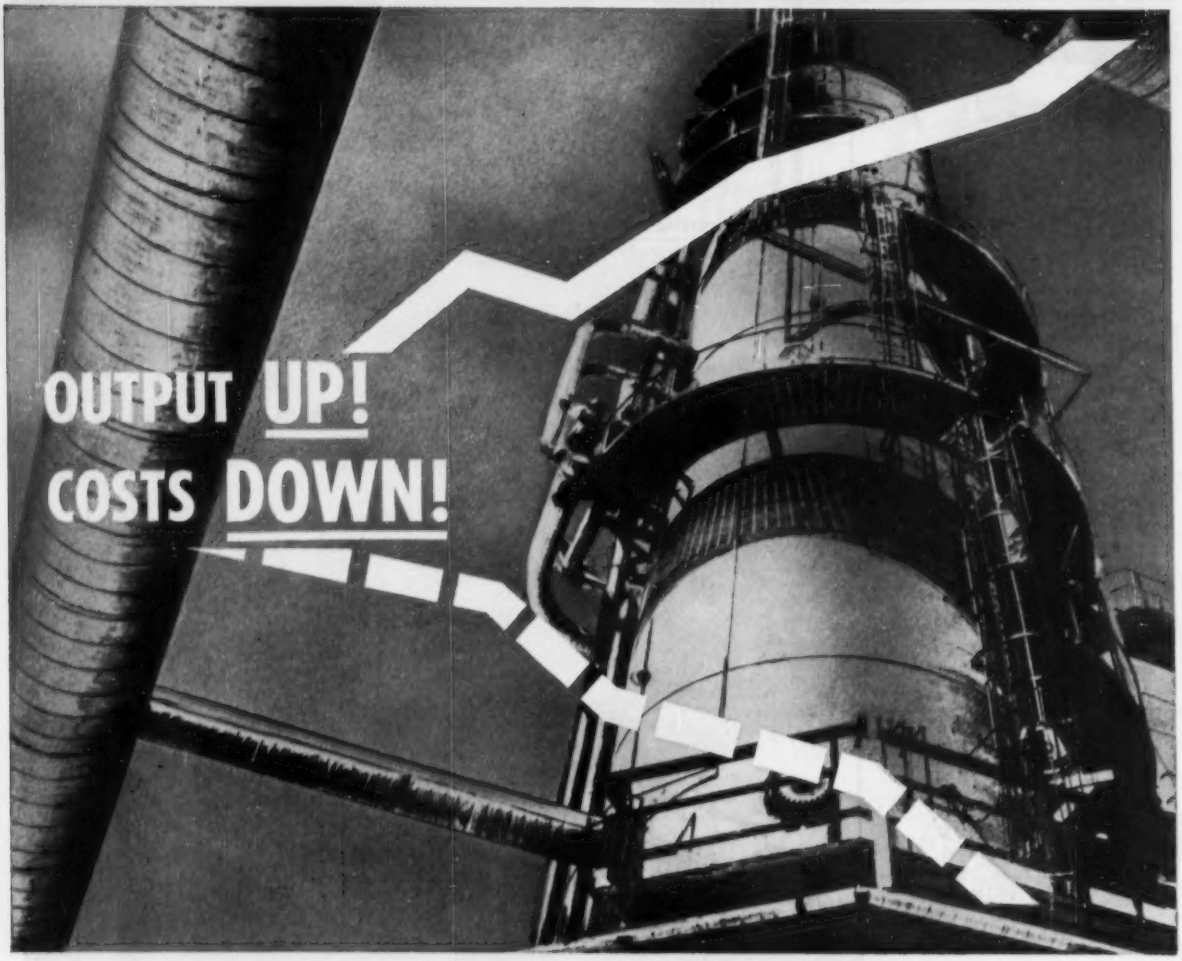
The only "bearingless" flow meter, the Pottermeter is unaffected by caustics, acids, corrosives and completely reliable even under extreme conditions of temperature and pressure.

Potter engineering has solved many "impossible" flow control problems. Maybe we can help you.

POTTER AERONAUTICAL COMPANY

Route 22, Union, New Jersey

For more data on advertised products, use Readers' Service Cards, last page.



with METEX Hi-Thruput MIST ELIMINATORS

METEX Hi-Thruput Mist Eliminators, installed in process towers and vessels, effect sharp separation of liquids and gases. Quality and yield are increased. Valuable liquids are knocked out and returned. Contamination of subsequent processing is removed. Turbines and compressors are protected from damaging liquids. Where build-up of coke or solids is a consideration, on-stream service life is increased three to four times. Air pollution is reduced, too.

METEX Hi-Thruput Mist Eliminators provide virtually 100% removal efficiency, even at extreme temperatures and pressures. Pressure drop is negligible. Their outstanding performance is due to repositioning of the wires by the METEX patented Herringbone Fold . . . an exclusive development of the originators of knitted wire mesh entrainment separators. Impingement target area is increased and stagnation points reduced.

In any processing equipment or vessels where liquid entrainment is a contributing factor in design or operation, specify METEX Hi-Thruput Mist Eliminators to assure greater production, improved quality of yield and substantially reduced operating and maintenance costs.

For complete information and specifications, write today for your free copy of Bulletin No. ME-6.

6-201

METAL TEXTILE CORPORATION ROSELLE, NEW JERSEY

Metal Textile Corp. of Canada, Ltd., Hamilton, Ontario • Representatives in principal cities throughout the world

Our Lubrication Engineers worked with Engine Designers, then put

EXTRA anti-wear protection in AEROLUBE® 93-C!

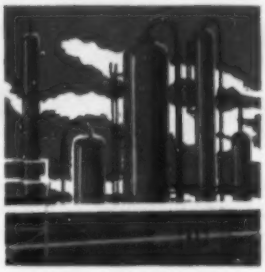
Top anti-wear characteristics are specifically formulated into Cyanamid AEROLUBE 93-C inhibitor to give the extra protection required in engine break-in, severe service or other problem conditions faced by lubrication engineers. This concentrated zinc dithiophosphate inhibitor safeguards stability—it is an excellent oxidation inhibitor that prevents formation of harmful peroxides and organic acids. It sharply reduces wear of valve lifters and other critical engine parts.

Zinc dithiophosphate has proved itself to be one of the most effective additives for commercial lube oils. Maximum wear resistance, oil stabilization and bearing protection, demanded by modern engines, have been built into Cyanamid's AEROLUBE 93-C.

Light color and compatibility with lube stocks and other additives, make AEROLUBE 93-C outstanding for use in premium oil products—for regular use as well as initial fill.

AERO® HDS CATALYST

In modern hydrodesulfurization processes, Cyanamid's new AERO HDS Catalyst contributes highest available volume activity and excellent mechanical properties. Cyanamid's specialized catalyst know-how may be helpful in initiating or improving your hydro-treating operation.



REFINING RESEARCH

At Stamford, Connecticut, the Refinery Chemicals Department of Cyanamid maintains laboratories unsurpassed in the refining field for basic research and development in catalysts and other refinery chemicals. As a part of extensive research and pilot plant facilities, specialized equipment and methods—such as the electron microscope and vapor-phase chromatography — are used to develop information leading to improved products which give optimum performance under field conditions.

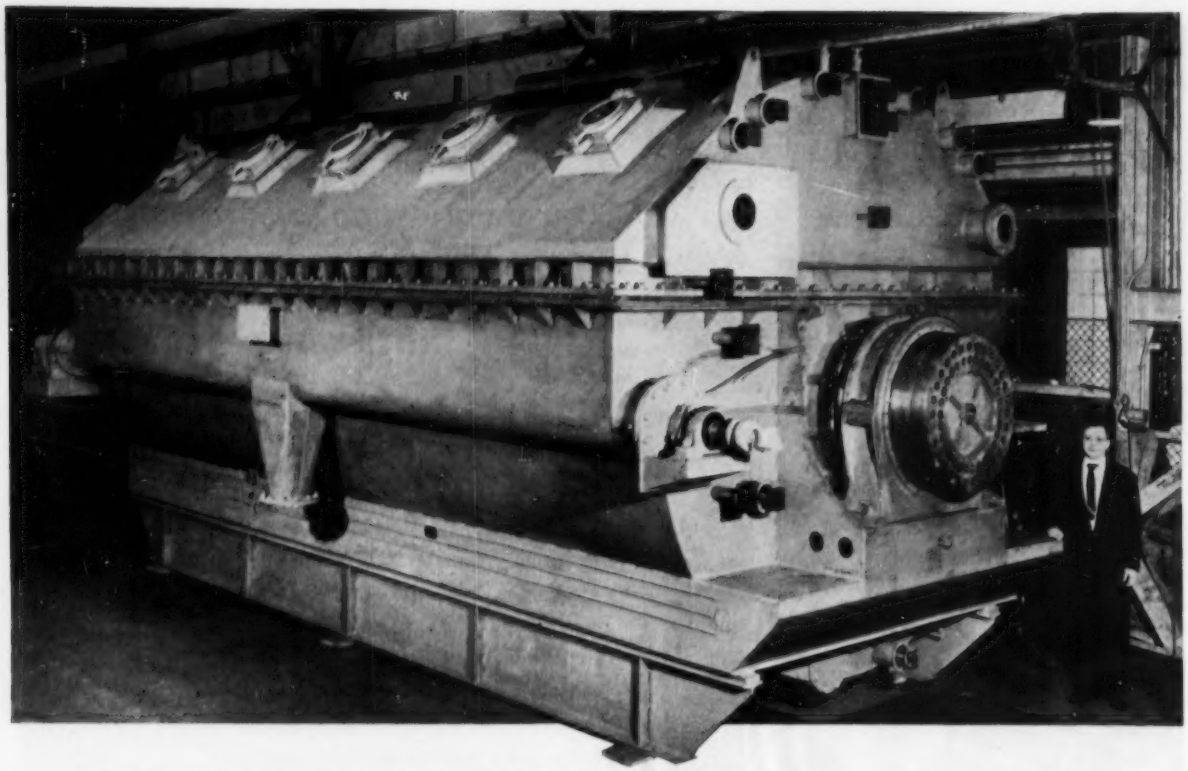
Our field men are constantly absorbing new developments at the research, development and operating levels. In this way, your Cyanamid man keeps abreast of the petroleum industry's dynamic technology and can offer a valuable technical service to refiners.

CYANAMID

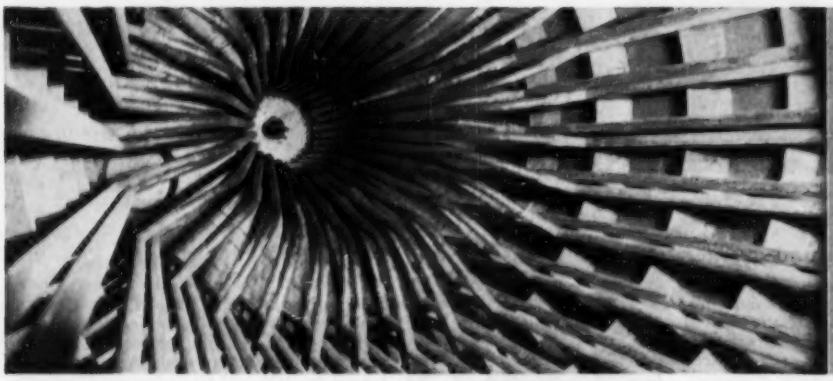
AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

For more data on advertised products, use Readers' Service Cards, last page.



World's LARGEST Petroleum Filters



One of six of the Oliver De-waxing Filters.

Internal drum exposure showing the pipes leading from the filter sections to the automatic valve in the trunnion.

Manufactured for a large mid-western refinery, each of these six MEK Oliver De-waxing filters measures 10′ in diameter, 22′ 3″ in length and has a filtering area of 700 square feet.

Oliver De-waxing Filters were selected for this installation because of large process capabilities, unique filtrate valve design, and a well-engineered internal drainage system.

Dorr-Oliver manufactures a complete line of filters for the petroleum industry. Other "World's Largest" . . . an Oliver pre-coat installation for breaking slop oil emulsions . . . and filtration stations for contact clay removal from lube stocks.

If you'd like more information on Oliver Petroleum Filters write Dorr-Oliver Incorporated, Stamford, Conn.

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New Copper Deactivator Guaranteed not to freeze!

This special all-weather UOP Copper Deactivator formulation will not freeze when stored for extended periods at temperatures down to 0° F. We call it Copper Deactivator-AW(50)*, since it contains active ingredient in 50% concentration. This new formulation completely eliminates the low temperature pumping problems common to other deactivators.

AW(50) gives maximum metal deactivating efficiency and economy. Improved color, too, and because of its better solubility and pumping properties, it can be injected directly into gasoline or other refinery streams without the customary dilution with aromatic spirits.

AW(50) is supplied in handy five-gallon containers for manual addition or blending with other additives and in 55-gallon drums for automatic injection systems.

*Trademark of Universal Oil Products Company

PRODUCTS DEPARTMENT

UOP **UNIVERSAL OIL PRODUCTS COMPANY**

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for Strength and Safety

GP GATE VALVE
SERIES 5-9530

Drop forging techniques, resulting from more than a half century of pioneering and development by Vogt in the production of forged steel valves, impart matchless strength and safety to the new line of Vogt GP Valves. Made from killed, clean, fine grained open hearth steel billets, forging and treatment operations result in additional grain refinement and increased toughness.

GP Valves are setting new standards of performance in petroleum refineries, chemical plants, power plants, and related industries. Available in a complete range of sizes from ¼" to 2" and rated 800 pounds at 850°F. and 2000 pounds at 100°F.

Advt. No. 4 in a series describing the features of Vogt GP Valves.

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VALVES

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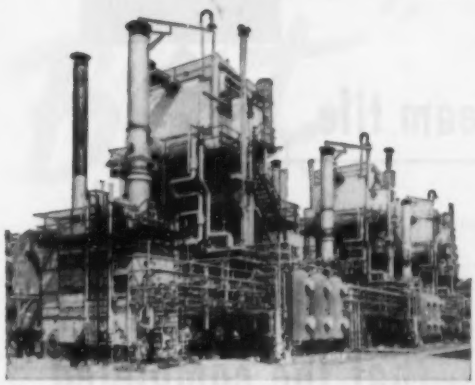
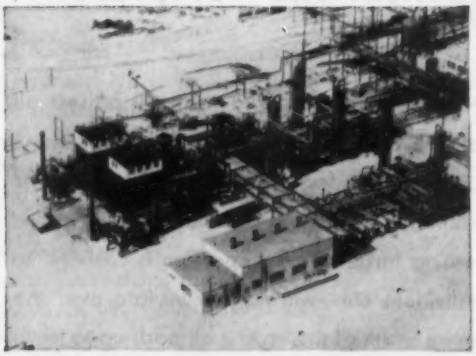
...how much do you need?

Girdler offers you complete engineering-construction service for BIG-CAPACITY *plants*





When you plan facilities for "tonnage hydrogen" for treatment of refinery feed stocks and hydrocarbon products, it will pay you to take advantage of Girdler experience.

Big plant experience: Girdler has designed and constructed large plants for petroleum products and chemicals. Two hydrogen plants have been built each of which can produce gas at the rate of seventy million cubic feet per day. More than 45 Girdler hydrogen plants are giving outstanding performance in the United States and Canada.

Girdler manufactures all of the catalysts used in Girdler hydrogen plants. These catalysts permit high production rates.

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The **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
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GAS PROCESSES DIVISION • DISTRICT OFFICES: New York, San Francisco

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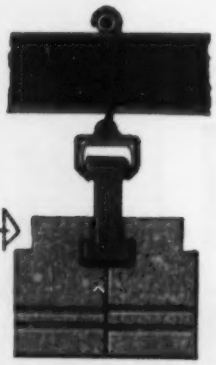
This tile is called a dog bone!

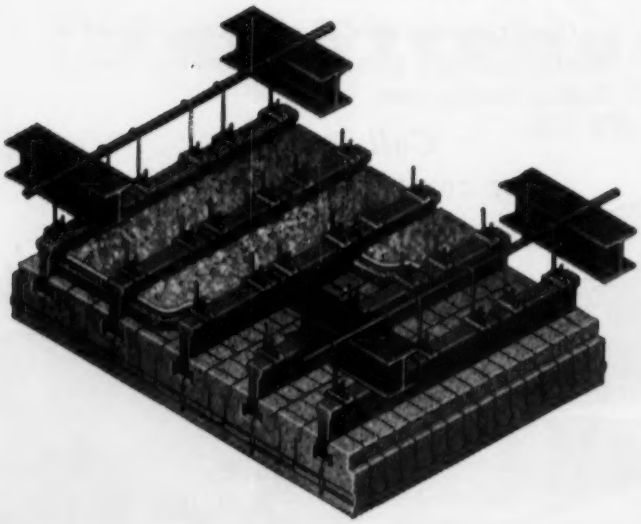
It's a husky supporting tile—used instead of an expensive alloy casting in a double suspended arch designed by B-L for high temperature aluminum, steel and glass furnaces. It can stand extremely high temperatures—can be used with or without insulation.

The dog bone supports two beam tile.



Bottom lugs are sloped so that the weight of the beam tile will draw the two together—like this:

Filler tile space out the arch so that the completed job looks this way:



Naturally the completed arch will possess all of the inherent characteristics of Bigelow-Liptak suspended construction. Burned out or damaged tile can be removed without disturbing large areas. Expansion is confined to individual tile—will not accumulate over the entire width of the arch. It all adds up to more production—less down time through keeping heat from raising the roof.

We'd like to tell you more about it. Just write.

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AND BIGELOW-LIPTAK EXPORT CORPORATION
2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

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"AT WESTERN
We don't build the most Heat Exchangers
. . . JUST THE "Best"

E. D. ANDERSON
Manager Heat Exchanger Division
Western Supply Company

Building the best heat exchangers at Western is the result of careful analysis of its facilities and potential as a manufacturer of engineered equipment, designed to fit the exact needs of each individual customer.

Western's modest size, its progressive manufacturing techniques and tools, its highly trained and skilled engineering and plant personnel—all contribute to the end result—the continuing patronage of its customers—new and old.

Realizing that the "best" heat exchanger is the one most accurately rated . . . most skillfully designed . . . most carefully fabricated . . . Western's manufacturing standards are consistently high.

Personal pride in their workmanship characterizes the skilled craftsmen in Western's shops, as well as the technical excellence of the design and engineering staff.

This careful attention to detail and the personal interest in each customer's needs means great savings from trouble-free operation and less maintenance after Western exchangers are installed.

Geared to serve those customers whose needs we best fit, Western will continue its established policy—"building the best heat exchangers".

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HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
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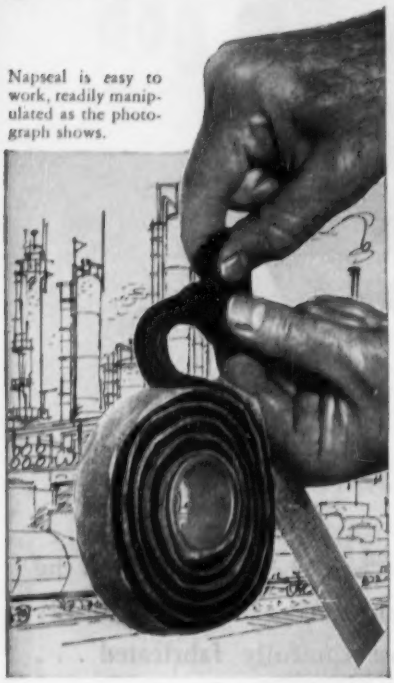
NEW

sealing compound resists gasoline and oil...



Napseal is easy to work, readily manipulated as the photograph shows.

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Napseal is the compound for those difficult sealing jobs where exposure to oils and fuels (including aviation gasoline) is encountered. Highly adhesive, it holds a tight seal, remaining permanently plastic in the presence of petroleum derivatives. Napseal retains its water tightness, will not dry out in service.

Napseal is easy to work and remains workable over a wide temperature range. It will not corrode metals or cause the deterioration of common substances in contact. Neither will it stain.

Napseal is handy for emergencies and other sealing needs. It requires no mixing, comes ready to use in beads, ribbons and 3" diameter pugs. Data sheet EL-64A gives more information. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Johns-Manville
SEALING COMPOUNDS

The Mail Box . . .

Praises Process Issue

To the Editor:

Your 1956 Process Handbook (September issue) is excellent. I know no other information on the present refining processes which is collected under one cover and contains a concise description of all these processes with references to the original literature. The flow sheets are also excellent; they show the essential features of each process without concealing them from the reader by the details which are of no interest to a person who is interested to find out what the basic differences between the processes are. Brief summaries of the general characteristics of the processes falling within the same classifications are very valuable as they present the over-all picture of the present status of refinery developments which may not be visualized otherwise. I am sure that no man connected with petroleum refining will miss the opportunity to have this wealth of information at his disposal. You should be proud of your achievement.

V. A. Kalichevsky,
Consulting Engineer
Beaumont, Texas

Heide Uses Urea

To The Editor:

We read with great interest in your August, 1956 issue that Standard Oil Company (Indiana) is building a new plant at Whiting which will use urea to dewax oils. This plant was said to be the first of its kind.

We should like to point out to you that we have been operating a commercial dewaxing plant using urea at the Heide refinery of the Deutsche Erdol-Aktiengesellschaft for more than a year.

We published an article on "The Production of Diesel Fuel and Spindle Oil of Low Pour Points by Means of Urea" in the June, 1955 issue of "Erdol and Kohle" a reprint of which we are enclosing.

Edeleanu Gesellschaft, M.B.H.
Frankfurt am Main, Germany

Likes Cost Article

To the Editor:

I am very interested in Thomas C. Ponder's article, "To Get More Plant for Less Money," which appeared in the October, 1956 issue of PETROLEUM REFINER and would appreciate a reprint of it when it is available.

K. S. McMahon,
Chief Process Engineer
Wyatt C. Hedrick Engineering
Corporation, Houston

Considered Invaluable

To the Editor:

Inclosed you will find a money order for which I would like to subscribe to PETROLEUM REFINER, and also receive a copy of your latest edition of the Process Handbook.

I attend a petroleum school here in Philadelphia and my teacher recommended your periodical to me. He also instructed me to be sure to obtain a copy of the Process Handbook which he considers invaluable. So I look forward to receiving a copy.

Edward J. McDevitt
Upper Darby, Pa.

Orderly and Logical

To The Editor:

Thank you for letting me see the September issue of PETROLEUM REFINER containing the 1956 Process Handbook. In my opinion you have done a very good job of presenting process information in an orderly and logical manner. I think the one-page general process descriptions that preface the various process groups are particularly useful and helpful.

Of course I am always primarily interested in processing that relates to gasoline manufacture and I have, therefore, read the reforming and treating sections carefully. I think it helps the descriptions significantly to give reforming data on as wide a variety of feed stocks as possible. This you have accomplished in many cases.

T. W. Warren
Ethyl Corporation
Detroit, Mich.

To Distribute Handbook

To the Editor:

If you could supply about 50 copies of your Author's Handbook, I would be pleased to pass them out to those who attend our Technical Expression Institute.

L. E. Johnston
Department of Engineering,
University of Wisconsin,
Madison.

How to IMPROVE Catalytic Cracker PERFORMANCE

YORKMESH DEMISTERS in Vacuum Towers effectively remove entrained asphalt to provide clean gas oil. The improved catalytic cracker charging stock with decreased carbon and metal contaminants results in —

HIGHER THROUGHPUT rates due to reduced load on the regenerator;

HIGHER YIELDS of liquid products due to high catalyst activity maintained for longer periods.

York engineers will review your operating conditions and recommend the best Demister from the several styles available, which include the new "Triple H" high-efficiency, homogeneous, herringbone Yorkmesh Demister.

WRITE for Bulletin 18 and Case Studies 1001, 1002 and 1004 from our technical library for specific information on vacuum tower installations.

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there's a touch of imagination in every good construction job

Brains, experience, technical skills, are all fundamental qualities in a good builder. These we have here at Procon in full measure. But, we try to add that vital touch of imagination that helps us visualize the correct answer to exacting new problems and enhances our ability to get each project completed to schedule and to every requirement.

Anywhere in the world, Procon offers the oil refining, petrochemical and chemical industries a complete construction service. Whatever your requirements, from complete new plant construction to expansion, modernization or the addition of process facilities, let us talk them over with you. This is the first step to a job completed to your full satisfaction.

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A Quick Look at the Industry THIS MONTH

Upswing in Contract Maintenance . . .

Petroleum Refiner survey shows growing number of refineries are contracting all turnaround and major repair work. However, older, large refiners are standing pat, *not* contracting maintenance because of established operations.

Example of New Refinery Trend: Tidewater's big new refinery at Delaware City, Del., recently contracted its maintenance work. Six more new refineries are considering.

At least five small refiners in Gulf Coast area are contracting all turnaround and major repair jobs—keeping small crew on hand for minor day-to-day maintenance work. **Six new petrochemical plants** are contracting—or planning to contract—all maintenance work.

Advantages of contract maintenance: Contractors say refiners have more control over contracted maintenance than they have over company union labor. Need to keep large maintenance staff on payroll is eliminated.

—•—

Business Outlook . . .

'56 business prospects are glowing—will top '55. Gross national product will pass $410 billion, up $20 billion over '55. Spiral to twirl thru '57. Some business seers see no deep recession or depression in next 20 years.

Despite bright outlook, watch for some questioning of current capital expansion programs. Thought is industry may be building too far ahead of market.

—•—

Refining Outlook . . .

After five weeks of cutbacks in refinery runs, product supply looks better than it has all year. Problem now is to keep stocks at present level during winter months. Another increase would seriously impair oil's supply position.

Gasoline and heating oils are leading refined products to healthy demand gain over '55. Gasoline demand at 3.9 million bpd is up 4 percent over year ago—distillate fuel oil at 1.6 million bpd is up nearly 10 percent.

Predictions are that oil consumption and exports will average 10.1 million bpd during November and December—6.4 percent above same months in '55.

Gloss is off the brass for crude oil price increase in '56. Reason: Supply-demand balance tilted too far toward supply excess. Big factor in over-supply has been disappointing increase in demand for gasoline—as good as it is, 4 percent isn't good enough.

—•—

Postings on Octane Race . . .

Race pace is slowing temporarily. Premium average has been holding steady at about 97F-1 octane. This doesn't mean race is ending—just a seasonal leveling off in accordance with past years.

Look for new upsurge to meet octane requirements of '57 cars.

Mark up Cities Service on "three" side in the two vs. three-grade competition. Company has just started marketing Ultra High Cities Service 100 plus, along with new top premium grade and new regular priced gasoline.

A Quick Look at the Industry (continued)

Jet Age Report . . . U. S. plane makers have received orders for more than 200 long range jet transports in past two years. Airlines will double present private investment when they complete these purchases—a billion dollar investment in the future.

—•—

New Trends in Electronic Brains . . . Prediction: Market for industrial electronic equipment will double in next five years. A new multi-billion dollar business is on its way—and refiners will be one of its biggest customers.

Development of device called "cryotron" (tiny piece of straight wire about 1/10 inch long, wound with single layer of control wire the size of a human hair) may have far-reaching effects on computers. One prediction is that a large-scale digital computer might be built that would occupy only one cubic feet of space. Operating power cost would be almost nil.

—•—

Atom and Refiners . . . Nearly every oil leader has had his say about effect atom will have on oil industry—and nearly every one agrees that:

- **Atom will have little effect** on product demand for at least 25 years.
- **Most feasible civilian use** will be for electrical generation. Only two percent of total oil products goes into this market—mostly residual fuel oil.
- **Radiation from nuclear fission** may be used extensively in refining to induce reactions of hydrocarbons to make fuel products and chemicals.

—•—

Asphalt Boom On the Way . . . Refiners are beginning to feel impact of big drive to get oil products accepted as road covering. Materials—once held for later fuel oil production—are now being sold for road construction.

Thanks to mammoth highway program, refiners can expect at least 30,000 b/d more demand for asphalt in '57—and even more in ensuing years. Result: Less residual fuel oil will be available with subsequent increases in price.

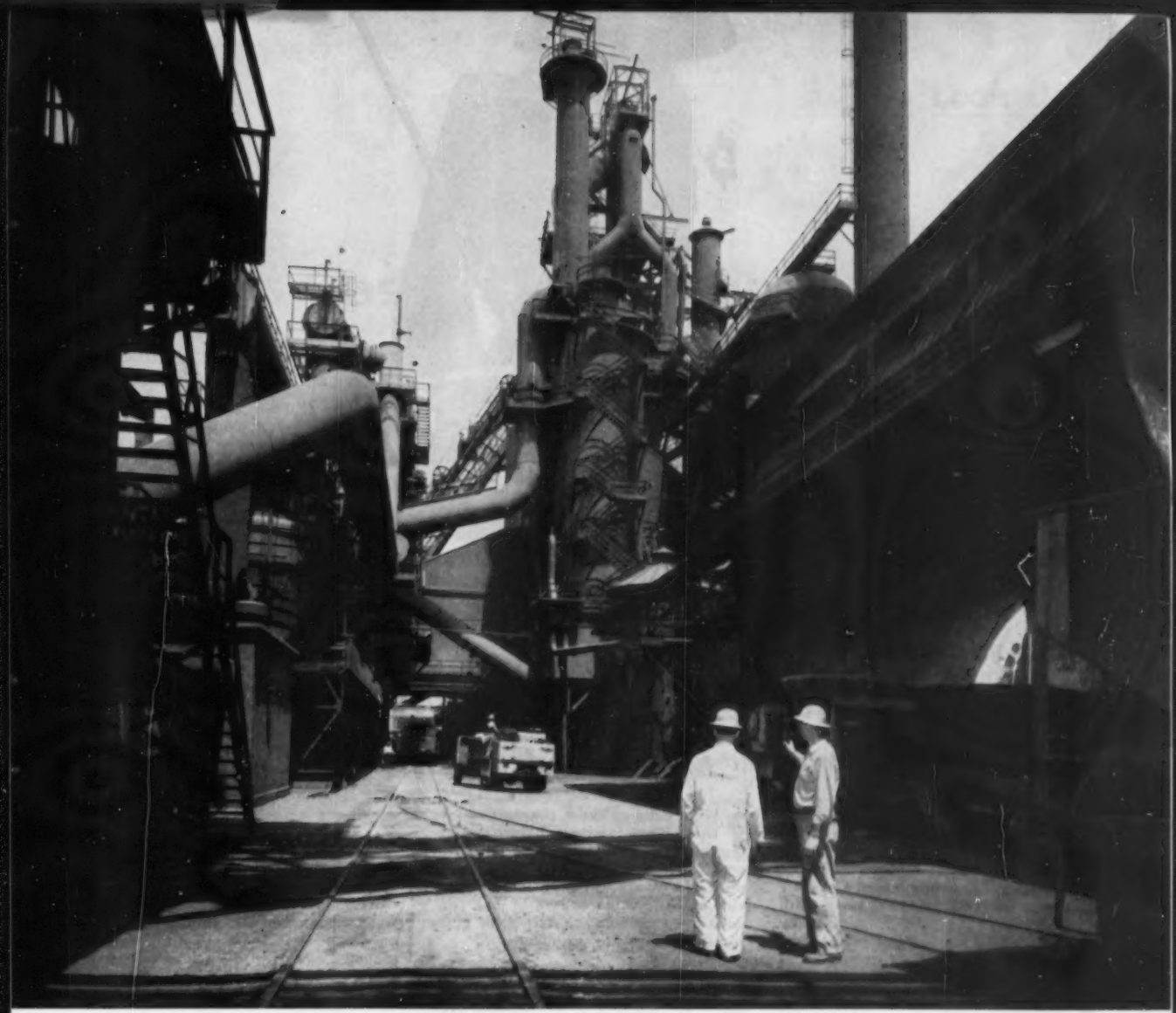
—•—

Rubber is Bouncing High . . . During past 18 months, U. S. consumed 30 percent of world's output of natural rubber. United Kingdom was nearest single consuming nation with a far-behind 12 percent.

If exports of synthetic rubber continue at present rate they will exceed 100,000 tons annually—surpassing '44 record of 98,380 tons. U. S. Customs show that 65.5 percent will be exported through Galveston and Sabine districts.

—•—

New Oil Fields Show Promise . . . Of the 86 new oil fields discovered in the U. S. during September several looked better than average. Two are located in San Juan County, Utah, drilled by Shell and Texas Company. Both tested at rate of 1400 barrels of 42 and 43-gravity of oil a day, respectively. Another by Texaco was completed in Hansford County, Texas Panhandle, flowing 1780 barrels of 39-gravity on test. Two sands produced 1300 barrels of 49-gravity and 100 barrels of 43-gravity oil in a discovery by W. E. Bakke in Andrews County, West Texas, and still another by Texaco in Terry County, West Texas, was good for 725 barrels of 36-gravity oil a day. Phillips and Texas & Pacific teamed to drill a 400-barrel, 41-gravity, discovery in Lea County, New Mexico. Sinclair's new find in Caddo County, Oklahoma, was good for 700 barrels of 38-gravity oil a day.



CHEMICAL CLEANING AT THE FORD MOTOR COMPANY, RIVER ROUGE, MICHIGAN

Dowell chemical cleaning gets results for Ford

When you have men and costly equipment in your care you don't take chances. That applies to chemical cleaning, too.

You—like Ford—want the company and the men who do your chemical cleaning to fulfill certain requirements. They must be as safety conscious as you are. This has to be your number one requirement.

Next, you want these men to have extensive experience so that you get the best possible job. And you want them to be backed by research facilities, because you know the best possible job can be done only when the latest developments are employed.

These requirements are basic with Dowell, as thousands of companies throughout the country can testify. You get them and many more when you have Dowell do your chemical cleaning.

Don't take chances. Have your chemical cleaning done by experts. When you want maximum safety and efficiency backed by research in your chemical cleaning—call Dowell. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. K-31.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Can you answer these **5 cost-cutting questions** *about big-tank mixers?*

If you can, you know how to get most efficient mixing for your company

1 How can I get mixer shaft seals that meet any operating conditions? It's easy—just standardize on LIGHTNIN Mixers for your big tanks. Get your choice of *four* standard stuffing boxes, or a wide choice of rotary mechanical seals. With LIGHTNINS, you're sure of getting the *right* shaft seal for years of trouble-free mixing or blending.

2 What's the advantage of LIGHTNIN cartridge-type rotary mechanical shaft seal? No stuffing box to repack or maintain. You can replace the LIGHTNIN Seal in minutes, if it ever wears out. No need to drain the tank or dismantle the mixer; no need for special skill—you're back in operation fast! Many users of the LIGHTNIN Seal are saving thousands of dollars per year with this exclusive feature.

3 What's the quickest, simplest way to shut off tank contents before repacking, or changing a seal? The LIGHTNIN way! Easy-to-get-at handles are out in the open, always accessible. A few turns provide quick, positive shutoff of tank contents from mixer. Only LIGHTNIN gives you this time-saving advantage.

4 What mixer gives me most protection of the drive gears? LIGHTNIN again! The mixer shaft, in LIGHTNIN gear drive models, passes through a hollow drive quill. Shaft and quill are supported by separate sets of bearings, connected only by a flexible coupling. This coupling cushions shaft flexures and strains—keeps excessive shock loads from ever reaching the gearing. This construction adds years of safe operating life.

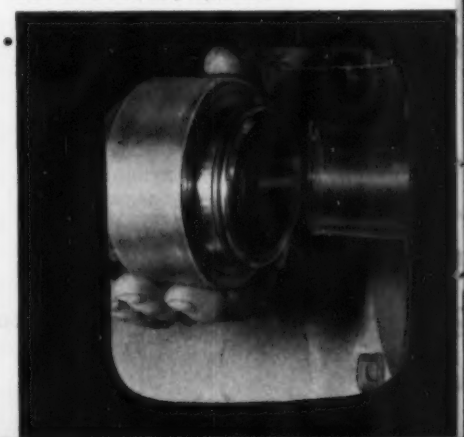
5 What's a good way to keep motor safe from dirt, dust, excessive moisture? Put the motor on top! This design, exclusive with LIGHTNIN, not only protects the motor; it centers weight closer to tank wall. You can choose standard foot-mounted motors, as shown, or round-frame NEMA Type P flange-mounted motors in all enclosures and all current characteristics. All motors are fully guaranteed.

These are just five of the engineering reasons why you get better, lower-cost mixing with LIGHTNIN Mixers. Your nearby LIGHTNIN representative can show you more. For quick, competent help on fluid mixing, look him up in Refinery Catalog. Or write us direct.

CUT MAINTENANCE COST with this quickly replaceable cartridge-type rotary seal, available on all LIGHTNIN Side Entering Mixers. Seal takes the place of a stuffing box; ends repacking for good; runs for years without adjustment; *slides off for fast, easy replacement.*

"Lightnin" Mixers

MIXCO fluid mixing specialists



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- ☐ B-102—Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP
- ☐ B-103—Top entering propeller types: ¼ to 3 HP
- ☐ B-104—Side entering: 1 to 25 HP
- ☐ B-108—Portable: ⅛ to 3 HP
- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110—Condensed catalog showing all types
- ☐ B-107—Data sheet for figuring mixer requirements

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-m Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.

Winter's Gasoline Will Bring Woes

THE U. S. REFINING industry has done a very creditable job of providing the facilities that insure the nation an ample supply of petroleum products. Not for several years has there been a semblance of oil shortage, nor should there be in the foreseeable future unless war intervenes. But the industry's zeal in providing the nation with this capacity has given rise to new problems for itself. Too much oil can never be as serious in consequence as too little, but top-heavy inventories can become burdensome and costly. For some time now the industry has been faced with the problem of gasoline accumulating excessively during the winter season.

Modern refining plants were designed and built to wring the greatest possible amount of gasoline, the money product, out of each barrel of crude. This gasoline yielding ability is one of the yardsticks by which refining processes are evaluated. The aim to get the greatest dollar realization from operations is certainly understandable and expected. The greatest income is obtained from gasoline; therefore, gasoline yields are held high. Results have been too much gasoline. It is as simple as that.

Not so simple are the solutions. With the tremendous amounts of capital already invested in the nation's refineries and the staggering amounts that must yet be spent to keep product qualities upgraded to answer competition, operators can ill-afford a lessened realization. If the price spread between gasoline and the distillate fuel oils was narrowed, refiners would have considerably more incentive than they do now to adjust their distillate yields upward, at the expense of gasoline output.

Even though demand for oils has been very good this year and reaching new peaks, the supply has been more than ample. In fact, it has been excessive. In the first nine months, consumption of oil products amounted to slightly more than 9 million barrels a day, which represented a gain of 5.8 percent over demand in last year's comparable period. However, supply of these oils amounted to almost 9.4 million barrels daily, and that was a hike of more than 8 percent over year-ago amounts.

That indicates that oil products supply amounted to almost 320,000 barrels a day more than was needed. Rate of consumption was up 500,000 barrels a day over last year's but supplies were laid in at a 700,000-barrel-a-day faster pace.

The industry failed to hold its supplies to seasonal requirements. Demand growth was substantially increased in line with expectations, but throughout the year, supplies topped needs.

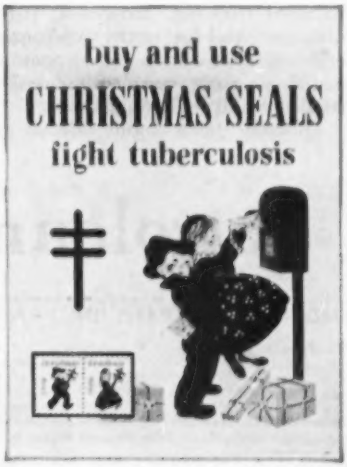
Over supply went into storage, and swelled inventories to a record 802 million barrels by the end of September. That represented an increase of 56 million barrels over stocks held a year earlier. In the first nine months, a total of 87 million barrels was added to the nation's inventory, while additions during the same period of 1955 amounted to only 31 million barrels.

The greatest part of the excess of inventories is in gasoline, a fact that is the cause of considerable concern in the industry. This year an excessive refinery rate clearly has been an important reason for this oversupply situation, according to John G. Winger, petroleum economist, The Chase Manhattan Bank. However, statistics reveal a more basic factor, he added.

"In the postwar period demand for gasoline has increased at an average per annum rate of 6.2 percent," the Winger statement said. "Distillate fuel use has grown much more rapidly, averaging 9.4 percent a year. But gasoline supply has increased faster than demand, while distillate supply has grown more slowly than demand. Obviously, the longer such trends continue the more serious gasoline over supply will be. The indicated solution appears to be in yield adjustments on a long term basis.

"Narrowing the price spread between gasoline and distillate would provide the incentive for such adjustments." Winger added, "The refiner, if he is to supply the high quality products in demand, cannot afford a smaller realization. Therefore, it seems that higher prices for distillates are called for." That would help refiners justify taking larger cuts of distillate and storing it during the summer months.

The events of the past 12 months provide a particularly vivid illustration of the urgent need for more prudent inventory management on the part of the nation's refiners, accord-



INJECTOR-STICKING is the problem at hand here. In this case, a combination of Du Pont FOA-2 and Metal Deactivator proved to be the solution.

Now—a new Du Pont Service to help you solve diesel-fleet fuel problems

When a diesel operator encounters a fuel problem—such as injector-sticking or filter-plugging—he often tends to blame the refiner for his troubles. And with a big fleet operator, such complaints are likely to jeopardize a substantial amount of business. It is at this point that your customer relations can often be improved by the analysis and opinions of a third party, a Du Pont technical representative backed up by numerous Du Pont facilities.

To help you solve these problems as quickly and easily as possible, our Du Pont Petroleum Chemicals Division automotive specialists will be glad to work with your men. Their practical experience with this type of problem can be added to your own experience. And our five conveniently-located regional laboratories, as well as the main Du Pont Petroleum Laboratory, can also aid you in this work.

In cases where filter-plugging occurs —in both truck and tractor fleets— our service representatives have found that Du Pont Fuel Oil Additive No. 2 (FOA-2), or a combination of FOA-2 and Du Pont Metal Deactivator (DMD) helps overcome the trouble. This same combination of additives has proved helpful also in overcoming injector-sticking. However, since different diesel fuel stocks vary considerably in composition and response to additives, each problem must be studied on an individual basis.

Different diesel engine injector designs may also affect the performance of fuels. We are, therefore, also working with diesel engine manufacturers on injector-sticking problems.

So if you are encountering fuel problems with any of your accounts, it may pay you to discuss them with one of our automotive specialists. And you can request this service through any of our offices listed below.

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ing to L. F. McCollum, president, Continental Oil Company. "The problem of short-term inventory management has become increasingly complex in recent years, largely because of fundamental changes in the seasonal pattern of demand," McCollum declared. "Not long ago, the combined demand for all petroleum products was nearly constant throughout the year—the summer bulge in gasoline demand was approximately balanced by the winter bulge in heating oil consumption. More recently, however, gasoline sales have run nearly as high in the winter as in the summer, a natural result of the improvements in highways and automobile performance. As a result, the demand for petroleum products now reaches a sharp seasonal peak during the month of January."

Changes which have taken place in the seasonal pattern of demand are illustrated by the fact that this year the demand for all products in May was 15 percent less than in January; ten years ago, the difference between the two periods was only 2 percent. This seasonal downswing in mid-year demand must be taken into account at all levels of the industry, McCollum added. Unless this is done, excess stocks will accumulate, and the price structure for products could well be undermined, he indicated.

By the end of March, high stock levels clearly suggested that caution was in order, but "our competitive enthusiasms blinded us to economic facts," McCollum said. "Refinery runs so far this year are up almost 7 percent over last, which was considerably higher than total demand had risen, and it is not surprising that the industry now finds itself with almost 24 million barrels more gasoline in storage than it had a year earlier.

"The present gasoline stocks hang heavily over the market, and future events will reveal the economic consequences of such an over-accumulation of inventories. If our present difficulties from overexuberant output and top-heavy stocks were unique, they might be passed over lightly as a first offense against the law of supply and demand. But a scanning of the record shows there is nothing novel about our present situation. It is apparent that we have steadfastly refused to learn from our experience."

"In view of these repeated experiences in the past, it is particularly distressing that we should once again be facing the potential consequences of unwise inventory management. We have seen time and again the excellent job this industry can do when it is called upon to produce in times of economic or military emergency. An equally important measure of our management ability is how well we can restrain our optimism in times of over supply. Our performance in this regard puts me in mind of a teenager driving a hot-rod. Jackrabbiting out when the signal changes, burning rubber by the yard. And for what?—Only to wait out the red light down at the end of the block."

Bottom-to-Top Opportunities

YOUNG MEN of integrity, initiative, loyalty and education, who have cast their lot with the oil industry, can get a real thrill from two pages of the Mid-Year issue of *The Texaco Star!* Most people in the oil business know that the industry awards its competent men but *The Texaco Star* told of:

- The retirement of a chairman of the board who had gone to work for The Texas Company as a lube salesman.
- The elevation to the chairmanship of the board of a man who during the depression went to work for the company as a service station supervisor, and
- The promotion to the presidency of a man who went to work for the company as a rotary rig helper.

True, these men had good educations but they went to work at the bottom and their loyalty to company interests, their native competence and their energy put them to the top without wealth—or pull.

The man retiring is chairman J. Sayles Leach, who received an award from the Texas Mid-Continent Oil & Gas Association as a man who had made real contribution to the industry. The new chairman is Augustus C. Long, and the new president who succeeded Long in that position is James W. Foley.

Power to them all as living examples of the way a free democracy, with free enterprise, works!

People and Circumstances

IT TAKES MORE than people to create a demand for oil products. We failed to stress this point in an editorial in our October issue.

Not often does PETROLEUM REFINER overlook such an opportunity. Publisher Ray L. Dudley, a most ardent advocate of free enterprise and the American way of life, sees to that. But to the case in point:

The editorial, "Fewer Plants—More and Better Products," carried a subhead "People Are Demand" which prompted this memo from Publisher Dudley:

"People are demand, it's true. Without people there would be no such word as demand.

"However, we must face the fact that there *are* people—over two billion, in fact—walking the face of this great globe. And the circumstances that determine demand differ with every geographical area. China with her hundreds of millions of people, USSR with her more than 200 million population, do not begin to equal the petroleum demand of the United States.

"The explanation is simple. It takes more than simply population to spell demand for petroleum or any other products. It takes the opportunity to earn what it costs to buy those things. Included with opportunity I would specify personal freedom—freedom to work along the lines chosen by the worker—freedom of action—freedom from fear. And by all means, freedom of enterprise, rather than the state of controlled enterprise."

There can be little question as to the validity of the reasoning in his memo. Don't you agree?

How to make octanes that count

by F. D. BUERSTETTA
Ethyl Corporation, Detroit, Mich.

Manufacture of high-octane gasolines to meet today's and tomorrow's automotive demands is putting increasing pressure on the refiner. Meeting these demands requires that the available hydrocarbon components in the refinery be blended to best advantage to give maximum performance on the road.

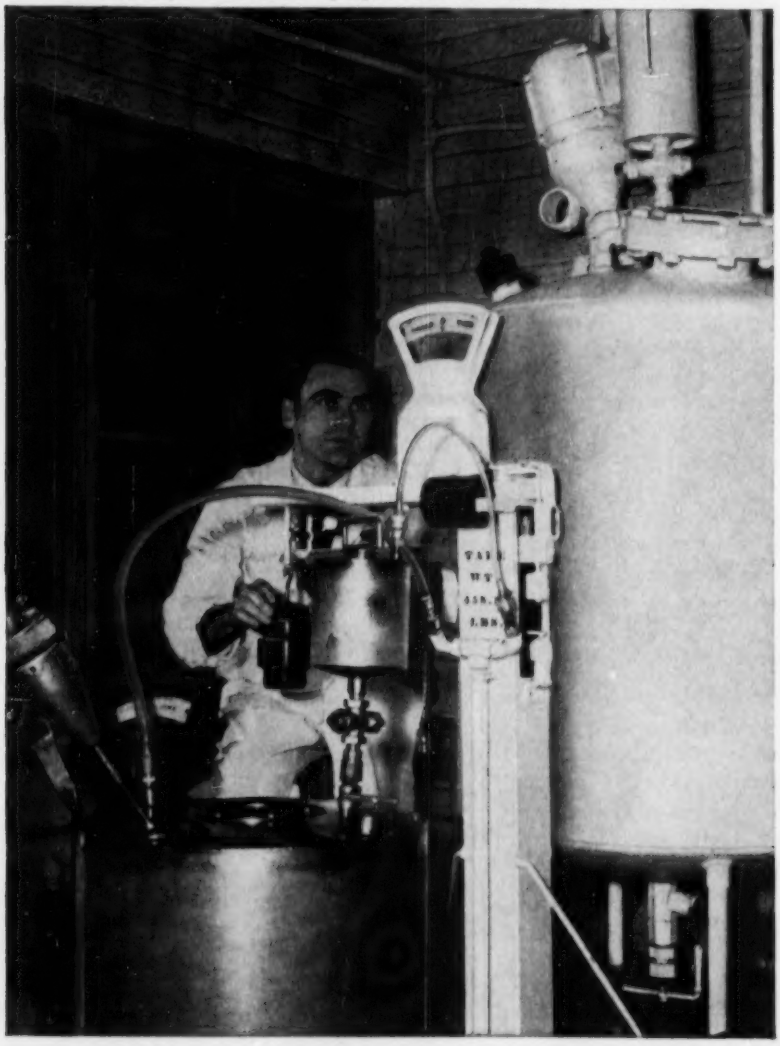
Each octane number at the 100 octane level may cost as much as 15 to 20 cents per barrel. Thus, there is a marked incentive for insuring that each laboratory octane number, obtained at this great expense, provide corresponding antiknock performance in cars on the road.

Hydrocarbon blends studied

As part of a continuing Ethyl Research program to establish the fundamentals of laboratory versus road antiknock quality, a study was conducted not long ago in which the behavior of blends of pure C_7 and C_8 hydrocarbons was examined.

Within this C_7-C_8 range, the four basic hydrocarbon types—olefins, paraffins, naphthenes and aromatics—were blended in varying proportions. Actually, a mixture of iso-octane and *n*-heptane was used as the paraffin constituent to permit maintenance of a constant Research octane number while investigating the effects of tetraethyllead concentration and variations in hydrocarbon-type composition. Toluene, di-isobutylene and methylcyclohexane were selected to represent the aromatics, olefins and naphthenes, respectively. Each of these hydrocarbons was blended in concentrations of 20, 40 and 60 per cent by volume with the proper paraffin mixture, giving nominal Research octane levels of 92, 96 and 100 at each of four tetraethyllead concentrations—0.0, 0.5, 1.5 and 3.0 ml. per gallon.

FIGURE 1. Accurate blending of pure hydrocarbon components at Ethyl Laboratories is the first step in the research program described in these columns.



Each blend was evaluated in laboratory test engines and was then rated in the 9-to-1 compression-ratio engine of a 1955 passenger car equipped with an automatic transmission. Ratings were made by both the Modified Uniontown and Modified Borderline techniques.

The results of that study were reported in detail in "Octane Possibilities with C_7-C_8 Hydrocarbons," copies of which are available on request to Department 34, Ethyl Corporation, 100 Park Ave., New York 17, New York. In general, it was shown that, on the basis of road appreciation (road rating minus Research method rating), highly leaded blends generally outperformed other blends of equivalent R. O. N., especially at high engine speeds.

New data available

Now, a second report in this series entitled "Octanes That Count" is available for your study. This new report compares the various toluene-paraffin blends and di-isobutylene-paraffin blends. Two 1955 passenger cars were used in this study and some interesting data on the effects of vehicle type were obtained.

These cars had V-8 engines of nomi-

(Advertisement)

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FIGURE 2. A test vehicle on the chassis dynamometer engaged in making one of the hundreds of road octane determinations reported in this Ethyl study.

nal 9.0-to-1 and 8.5-to-1 compression ratios and were selected because these engines represent extremes in fuel-rating characteristics.

In order to bracket the maximum octane-number requirement of the two cars used in the study, the test blends were formulated at three different Research octane number levels. Road ratings obtained at these octane-number levels permitted an estimation of the Research quality of a blend which would just satisfy the antiknock requirements of a vehicle at any engine speed. Comparisons of fuel behavior made in this manner eliminate the possibility of obtaining ratings at overly advanced or retarded spark settings. It is believed that a study of this type provides a realistic appraisal of the relative merits of hydrocarbon type and TEL concentration.

Conclusions

Based on the Research octane number of fuels required to give knock-free operation at various engine speeds under normal conditions, the following generalizations can be made:

1. At high engine speeds (3000 RPM):
   a. Toluene-paraffin blends are superior to di-isobutylene-paraffin blends of equivalent hydrocarbon insert concentration and TEL level in both cars tested.
   b. The Research octane number of fuels required to satisfy either car, regardless of hydrocarbon type and concentration, decreases at higher TEL concentrations.
2. At low engine speeds (1000 RPM):
   a. Toluene-paraffin blends and di-isobutylene-paraffin blends are, in general, equally effective in meeting the vehicles' antiknock requirements. Exceptions are the blends with high concentrations of both TEL and hydrocarbon inserts. For these conditions, the toluene-paraffin blends excelled in one car and were slightly inferior in the other.
3. As the concentration of either toluene or di-isobutylene is increased in blends at any given TEL level, the Research octane number of blends required to satisfy one vehicle increased—and the octane number required to satisfy the other vehicle decreased. Thus, highly paraffinic blends showed superior performance in one car and inferior performance in the other used in this test.

How Ethyl Research can help you

At today's high octane levels, the art of blending hydrocarbons has taken on more and more importance. As a service to the oil industry, Ethyl Research has launched a hydrocarbon blending program of its own to complement the intensive effort which the industry is devoting to this problem.

We are now testing many new blends in our laboratories and in high-compression engines on the road. Much of the data from these tests is being interpreted in terms of "road appreciation" to give refiners a better idea of the effectiveness of each blend. Write Department 34, Ethyl Corporation, 100 Park Ave., New York 17, New York, for a copy of "Octanes That Count"—another in the continuing series of reports from the Ethyl Corporation on fuel blending and other studies of vital interest to refiners today.

For further information, just call your Ethyl Representative. He'll be happy to arrange an appointment for you with one of our Technical Representatives.

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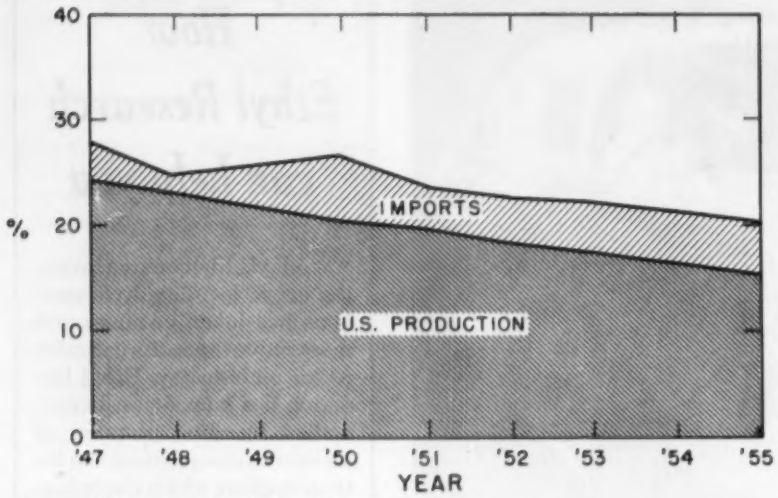


U. S. Consumption of Residual Fuels (As percentage of domestic crude runs).

Will Atomic Energy Replace Oil?

Not in the foreseeable future, says the top official of one of the oil industry's largest corporations.

Robert E. Wilson
The Standard Oil Company (Indiana)
Chicago

"WHILE THE development (of atomic energy) is highly important to the nation and the world, the impact on our industry will be negligible over the next 20 to 25 years.

"Beyond that, I believe we will gladly welcome the aid of atomic energy in helping to take care of the country's growing needs for power."

This prediction of oil's future in the atomic age was presented to the Energy Resources Conference in Denver, Colo., October 29. The author was Board Chairman Robert E. Wilson of Standard Oil Company (Indiana). Wilson's statements (delivered by Executive Vice President John E. Swearingen) regarding the effect atomic energy will have on specific oil products are as follows:

Effect on Residual Fuels—Heavy residual fuel oil would be almost the only oil product affected, as it is the only one in substantial use by central power plants. While the over-all consumption of heavy fuel oil has been growing slowly, when expressed in percent of domestic crude runs, both total consumption and United States production have been declining since the end of World War II.

Over the past nine postwar years, our over-all consumption of heavy fuel oil has decreased from 28 percent to 20 percent of the volume of domestic refinery runs. Our production from domestic refinery runs has been cut from 25 percent to 15 percent. If the figures were in dollars, the percentage would be still lower.

Residual fuel is our least profitable product—the only one selling for less than the cost of crude oil. As a result, we have been steadily reducing our yields and converting more and more of our residual oils into more valuable products.

Moreover, only 10 to 15 percent of our residual fuel is used to generate electricity.

In fact, the total amount of residual fuel used for power generation in the U. S. in 1955 represented less than 3 percent of the total volume of crude run; and here again the percentage would be even smaller if expressed in dollars.

So, even if we lost all our central power-plant business during the next 25 years, we would hardly notice it; in fact, we are likely to lose most of it to coal before that, and no tears will be shed. Certainly, long before we seriously undertake to make motor fuel from coal, we will burn more coal in power plants and convert our residual fuel into gasoline, at much lower cost than we could make gasoline from coal.

While a small proportion of our lighter distillate fuels is also used to make power, this is mainly in very small plants where atomic power would hardly be considered, except possibly in remote locations where transportation costs may be several times as large as the basic cost of the fuel.

What about fuel oil for ships, which today take about 20 percent of our residual fuel oil? While some submarines and possibly other special naval vessels will be atomic powered for war service, it is felt that the comparatively high first cost of atomic power plants of moderate size and the hazards involved will make their use on commercial ships develop even more slowly than in large central power plants. But again, if we should lose the fuel oil business of some of

the larger new ships after 15 or 20 years—what of it?

Effect on Natural Gas Demand—Natural gas, also, is used as fuel in power plants, having gone from about 10 percent to about 20 percent of the total in the last 10 years.

Outside of the gas-producing areas, it is used today largely because it is available as off-peak or "dump" gas at low prices during the warmer seasons when the big gas pipe lines from the producing areas would otherwise be operating far below capacity.

The availability of dump gas at such low prices will tend to decrease as the older supply contracts expire and as more facilities for the underground storage of gas are put into service near consuming centers. These facilities will make it possible to keep the long pipe lines running nearly full the year round, the summer excess being stored in order to have it available for winter household consumption at higher prices.

The use of natural gas for power generation outside the gas-producing areas can be expected to begin to decline gradually within the next few years, whether or not atomic energy begins to compete, and again few tears will be shed by the gas producer or transporter over gradually losing this very low-priced market.

The higher priced markets for gas are bound to continue their rapid growth—the only question is whether federal price control of the producer will stifle new discoveries. An interesting sidelight on the importance of natural gas is the fact that while it weighs only 56 percent as much per cubic foot as air, last year's production weighs about 2½ times as much as the nation's steel production!

Doubt Use of Atomic Fuel in Land Vehicles—How about atomic fuel for locomotives, or for cars, buses, and trucks? In this field of land transportation lies, of course, the oil industry's principal market. The only use of atomic power in land transportation which is being seriously discussed as a possibility is in a large locomotive. The fact that the locomotive would always be moving when generating much power would tend to reduce the shielding necessary, except for those operating it.

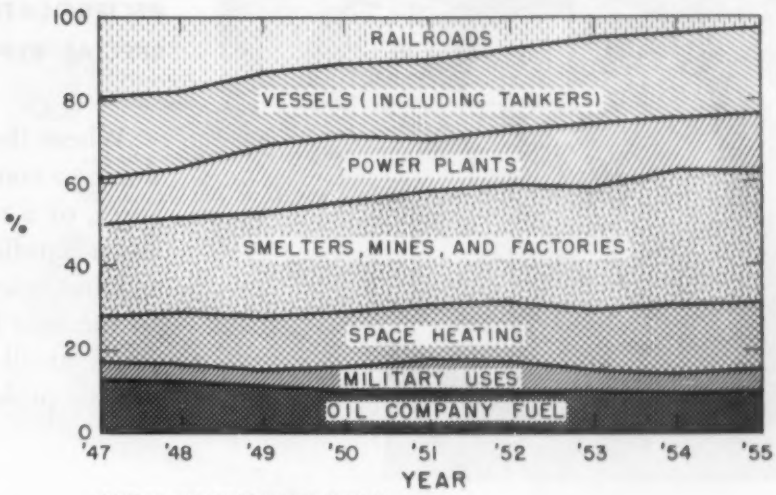
However, even if an atomic-powered locomotive should prove to be both safe and economical in normal service (which is very doubtful), it is difficult to imagine either the railroads or the regulatory authorities being willing to risk a possible wreck of an atomic engine in one of the large cities. While a theoretically safe shielded "package" might be designed, the psychological factors would probably bar it for many years.

Either a gas turbine or a resurgence of electrification for dense traffic would seem more probable, if diesel fuel costs should eventually climb too far above present levels.

For cars, trucks, or buses the idea is fantastic. Even supposing people could afford the minimum conceivable cost of many thousands of dollars for an atomic engine, we would have to have a steel or concrete dashboard several feet thick to protect the passengers from dangerous radiations, and similar sidewalls to protect the passers-by.

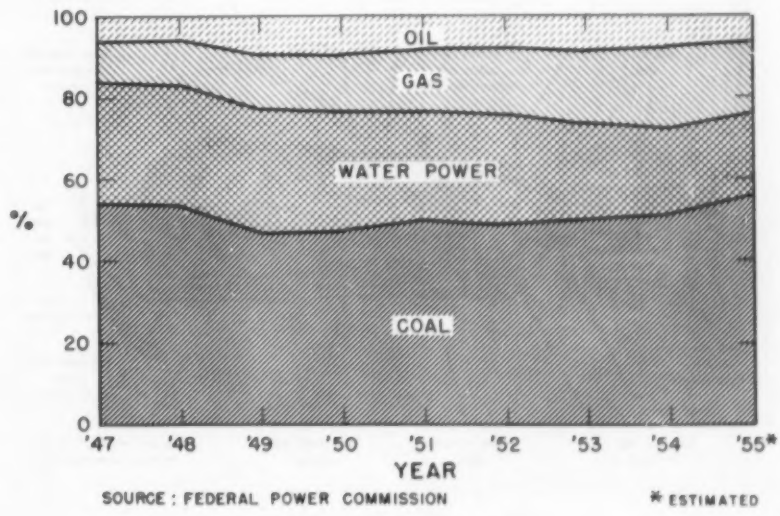
For commercial passenger planes, too, the shielding problems seem to constitute an almost insuperable bar, though it might be feasible to shield the crew of a very large bomber or cargo plane. The weight of needed shielding on such a plane has been estimated at around 50 tons! However, the military value of a plane of unlimited range is so great that over $200 million has been spent on the general project, and such a plane

Continued on Page 250



SOURCE: U.S. BUREAU OF MINES

Sales of Residual Fuel Oil by Uses.



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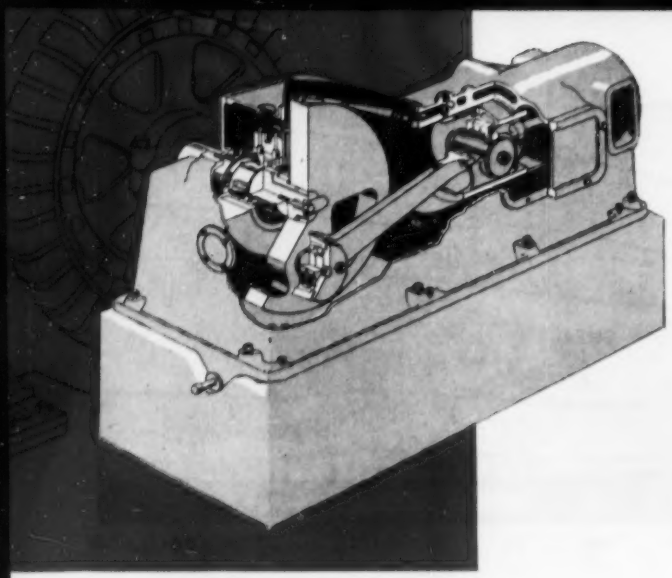
Sources of U. S. Electricity.



RECIPROCATING COMPRESSOR SPECIAL REPORT . . .

Where the need is for a compressor producing a constant-capacity at variable pressures, or a need for the same pressure rise when handling gases of varying molecular weights, select a reciprocating compressor. In the next five articles, you'll find the answers to all phases of reciprocating compressor problems.

1. Introduction to Principles — be sure you've got the right type for the job.

J. E. Cumiskey
Chicago Pneumatic Tool Company
New York City

A RECIPROCATING compressor raises the pressure of a gas by the forced reduction of its volume through the movement of a piston—positive displacement of the gas within the confines of a cylinder.

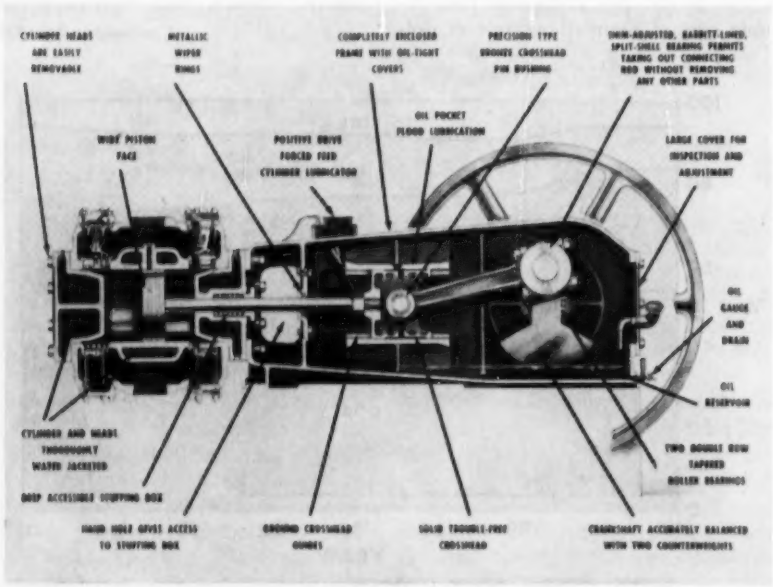

CYLINDER HEADS ARE EASILY REMOVABLE
METALLIC WIPER RINGS
COMPLETELY ENCLOSED FRAME WITH OIL-TIGHT COVERS
PRECISION TYPE GROOVE CROSSHEAD PIN BUSHING
SHIM-ADJUSTED, BABBITT-LINED, SPLIT-SHELL BEARING PERMITS TAKING OUT CONNECTING ROD WITHOUT REMOVING ANY OTHER PARTS
OIL POCKET FLOOD LUBRICATION
WIDE PISTON FACE
POSITIVE DRIVE FORCED FEED CYLINDER LUBRICATOR
LARGE COVER FOR INSPECTION AND ADJUSTMENT
OIL GAUGE AND DRAIN
OIL RESERVOIR
CYLINDER AND HEADS THOROUGHLY WATER JACKETED
DEEP ACCESSIBLE STUFFING BOX
HAND HOLE GIVES ACCESS TO STUFFING BOX
GROUND CROSSHEAD GUIDES
SOLID TROUBLE-FREE CROSSHEAD
CRANKSHAFT ACCURATELY BALANCED WITH TWO COUNTERWEIGHTS
TWO DOUBLE ROW TAPERED ROLLER BEARINGS

FIGURE 1—Cross-section view of simple single-stage compressor.

Similarly, the sliding-vane, lobe, and liquid piston compressors are classified, with the reciprocating, as positive displacement compressors since increased pressure results from a physical reduction in the gas volume. The method used to achieve this reduction in volume differs with each type of positive displacement compressor.

Centrifugal and axial flow compressors are dynamic machines, so called because pressure results from a conversion of the energy imparted to the gas by the action of blades or impellers.

In the broader sense, reciprocating compressors can be classified into two groups, i.e., air-cooled and water-cooled. With the exception of some pipeline and packaged refrigeration compressors, air-cooled machines are generally single-acting, high speed units designed for intermittent service, handling air. The water-cooled, double-acting compressor is by far the most common reciprocating compressor found in refinery and petrochemi-

cal processes and we shall therefore restrict our discussion to this water-cooled type.

To properly evaluate the many reciprocating designs presently marketed, it is necessary to first define the component parts of the equipment and to understand the function of each of these components.

Basic Design—Figure 1 illustrates a cross-sectional view of a horizontal, single cylinder, single frame water-cooled compressor—the simplest of all reciprocating compressors. Larger and more complicated machines embody the same basic parts such as cylinders, pistons, crossheads, crankshafts, frame, etc., so that a knowledge of this fundamental construction will facilitate the understanding of more complex designs.

Cylinders—Of prime importance in the reciprocating compressor is the design of the cylinder, its valving and water-jacketing. For low compression ratios, or where the gas handled is extremely heavy, the cylinder must be adequately valved to keep valve velocities and losses low, and to insure the best obtainable compression efficiency.

At compression ratios of 3 to 1 or more, there is a definite need for liberal water-jacketing to reduce preheating losses which tend to lower compression efficiency. Adequately jacketed cylinders will, at higher ratios, give better performance although in gas work it is sometimes necessary to forego these benefits in order to prevent gas condensing on cold cylinder walls.

Valves—Present day intake and discharge valves operate strictly on differential pressure. When the pressure within the cylinder is slightly below that in the suction line, the inlet valve will open. When the pressure in the cylinder exceeds the pressure in the discharge line, the exhaust or discharge valve will open. As the gas enters a double-acting cylinder, it is compressed alternately in the crank-end and head-end of the cylinder with piston rings being used to prevent blow-by from one end of the cylinder to the other. The piston rod packing, usually vented for gas work, minimizes the leakage of gas from the cylinder along the piston rod.

If the gas compressed is easily condensable, it is wise to insist on horizontal cylinders with discharge valves and ports located at the bottom. So arranged, the cylinder can more readily relieve itself should condensate form.

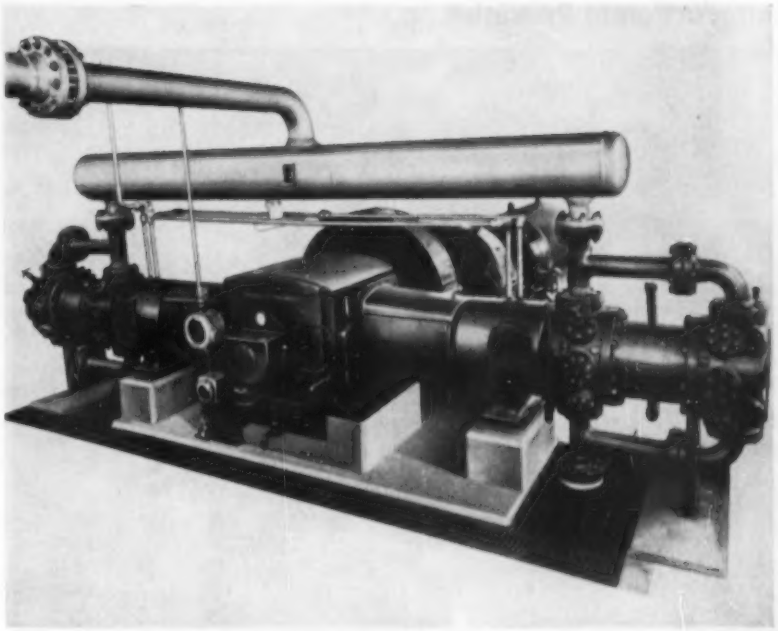


FIGURE 2—Two cylinder recycle gas compressor driven through a reduction gear.

Frame and Running Gear—The cylinder connects directly to the compressor frame or to a distance piece interposed between the two. The distance piece, when used, can be of the open type or enclosed pressure type depending upon the purpose intended. The frame, made of cast iron or fabricated steel, houses the running gear consisting of the crosshead, connecting rod, crankshaft and necessary bearings. A flywheel may be necessary depending upon the WR^2

TABLE 1

Reciprocating compressor types and ranges generally manufactured.

TYPE	Horsepower Range	Pressure Range
Horizontal, Straight-line	10–150	Vacuum to 7500 psig
Horizontal, Duplex	200–1000	Vacuum to 15000 psig.
Horizontal, Duplex, four-corner:		
Motor Drive	700–2000	Vacuum to 15000 psig.
Steam Drive	200–1500	Vacuum to 15000 psig.
Horizontal, Balanced-opposed	150–5000	Vacuum to 15000 psig.
Vertical	25– 450	Vacuum to 1000 psig.
"V", "L", "T" or Semi-Radial	60–1000	Vacuum to 5000 psig.
Angle-engine Compressors	100–2500	Vacuum to 15000 psig.

TABLE 2

Choice of a driver often determines which compressor to use.

	DRIVER						
COMPRESSOR TYPE	Belted Driver	Direct-Connected Synchronous Motor	Direct-Connected Induction Motor	Gear Drive with Motor or Turbine	Integral Steam Engine	Coupled Engine Drive	Integral Gas, Diesel, Dual Fuel or Tri-Fuel Engine
Horizontal, Straight Line	X	X		X	X		
Horizontal Duplex	X	X			X		
Horizontal Duplex, Four-Corner		X			X		
Horizontal Balanced-Opposed		X	X	X		X	
Vertical	X	X	X	X		X	
"V", "L", "T" or Semi-Radial	X	X	X	X		X	
Angle Engine Compressors					X		X

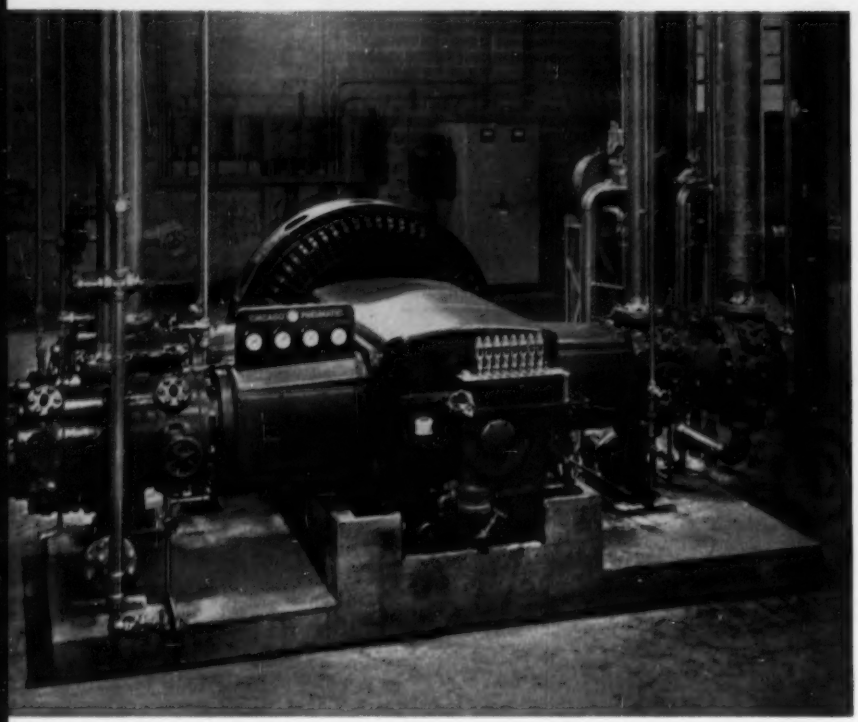


FIGURE 3—Three-stage, high-pressure compressor with direct mounted engine type synchronous motor drive.

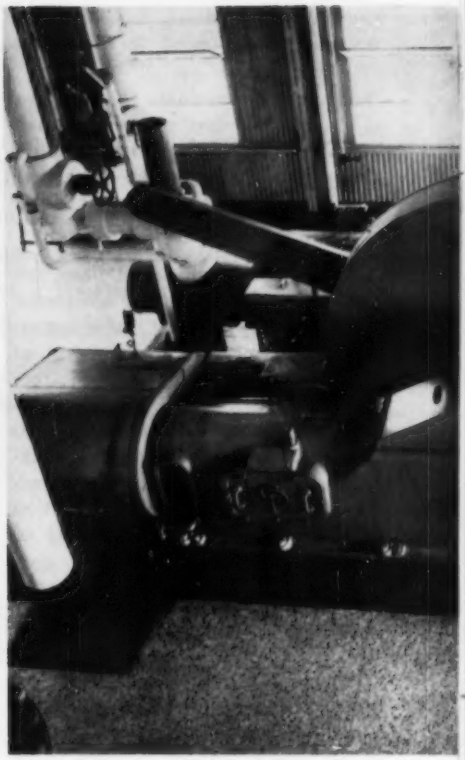


FIGURE 4—Duplex "steamers" put excess refinery steam to work.

required to impart a reasonably smooth crank effort. Most any type of driver is satisfactory, i.e., belt, direct connected motor, gear and motor, gear and turbine, integral steam, gas or diesel engine.

These are the basic components. Now let's look at the many variations in cylinder arrangements and the basic sizes available. Pressures tabulated in Table 1 indicate the general range presently manufactured. However, they are by no means the limiting pressures on a reciprocating machine. Where process requirements, such as the production of polyethylene, dictate higher pressures, reciprocating machines can, and have been furnished for 35,000 pounds per square inch gage operation.

It is important to realize at the outset that frequently the choice of the right compressor for a given job is determined by the driver. The most widely used and economical type of compressor drivers presently employed are tabulated in Table 2.

Figure 2 shows a two-cylinder, single stage, non-lubricated, balanced-opposed hydrogen recycle compressor driven through a reduction gear by a 1750 rpm squirrel cage motor. Special two-compartment distance pieces are used between the cylinders and frame. Incidentally, where process requirements dictate that compressed gas must be oil-free, reciprocating compressors can be supplied with carbon piston rings and piston rod packing to eliminate oil contamination. Water soluble lubricants can also be used. The balanced-opposed arrangement, with its crankshaft extension, can accommodate many different prime movers and Figure 3 illustrates a three-stage, high pressure, carbon-dioxide compressor with direct-mounted engine type synchronous motor drive.

In a refinery there is usually some excess steam that can be put to work driving a compressor. The horizontal, duplex, four-corner, "steamers" shown in Figures 4 and 5 are doing just that. Steam throttle pressures between 80 and 250 psig, and in some cases as high as 400 psig can be readily handled by integral steam engine driven machines. For higher steam pressures it is necessary to use a steam turbine such as shown in Figure 6.

Since the gas being compressed, number of compression stages, maximum discharge pressure, total horsepower and prime mover exert great influence on the initial cost of the reciprocating plant, it is very difficult to generalize as to the magnitude of this first cost. For example, it's common practice in sizes 125 hp and

Meet the Author

JIM CUMISKEY was born in 1925 in LaPorte, Indiana, and attended Columbia University and Tufts College. He received his Bachelor of Naval Science degree in 1945, and a B.S. degree in mechanical engineering in 1947. Cumiskey joined Chicago Pneumatic Tool Company in 1947, and presently holds the position of Assistant Manager Compressor Division.

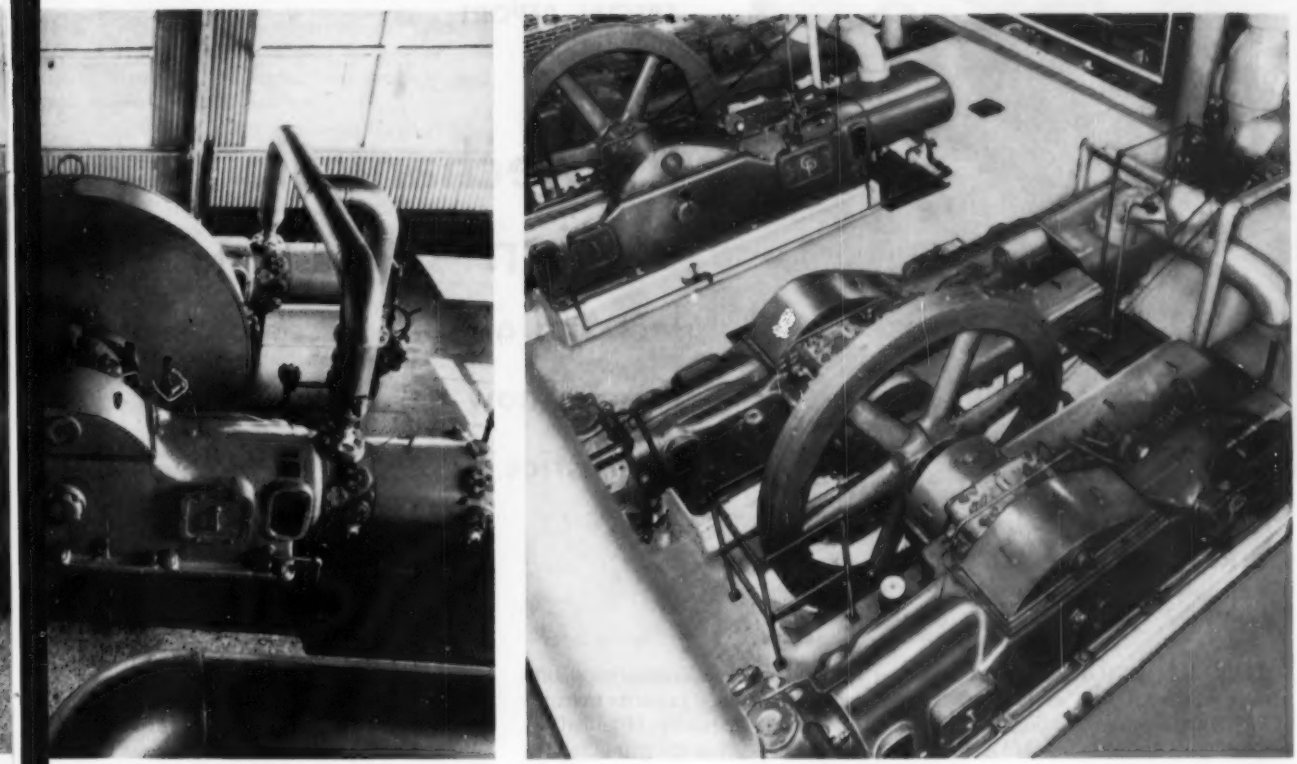


FIGURE 5—Steam-driven compressors handle throttle pressures between 80 and 250 psig.

below to compress air or nitrogen from atmospheric pressure to 1500 psig in three stages. However, if the gas were helium, or if the total power required was much above 125 hp, four stages would most certainly be used.

There is no "cold war" between the reciprocating and centrifugal compressor. Each type has its particular applications and only occasionally will the situation arise when each design could be used equally as well. There are instances where both types have been used to advantage. The centrifugal has been employed as the primary machine handling the large volumes at low pressures, and the reciprocating equipment as booster units to raise the gas to final discharge pressure. In general, where very large volumes are required at low compression ratios, the centrifugal machine will outshine the reciprocating compressor. With higher compression ratios, reciprocating compressors are used. A reciprocating compressor is more efficient and therefore will require less horsepower than a centrifugal unit designed for the same capacity and pressure conditions. Further, the output capacity of a reciprocator can be readily controlled by speed variations, inlet valve lifters, fixed or variable volume clearance pockets or a combination of all four. On the other hand, centrifugals are controlled by speed changes or throttling—the latter method being quite inefficient.

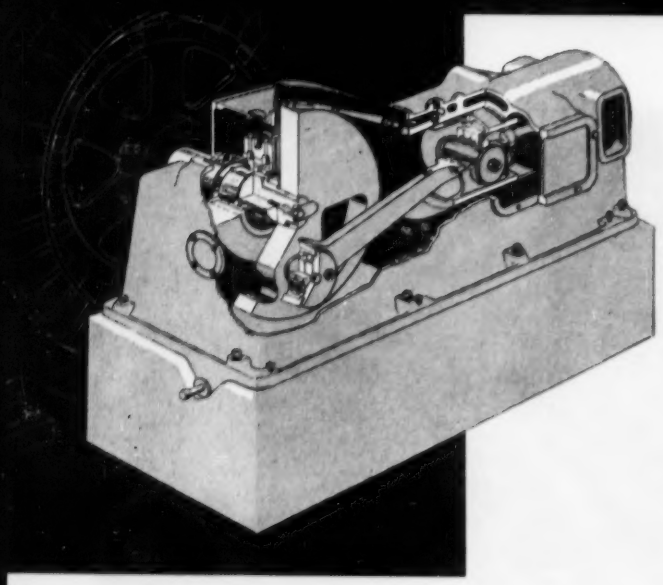
Because of their high rotative speeds, the centrifugals lend themselves readily to steam or gas turbine prime movers. In many cases they can be directly coupled. If a motor or engine drive is used however, the problem of speed-increasing gears is introduced and these gears, because of the high speed required by the driven equipment, are most costly.

Obviously then, reciprocating equipment is more readily adaptable to the various types of drive encountered in refinery service and even if intermediate gearing is necessary, it is usually the low speed type and therefore less expensive.

Since molecular weight or gas density appreciably affect the sizing and performance of a centrifugal compressor, while not seriously affecting the reciprocating machine, compression of lower gravity gases generally favors the reciprocating unit. Further, if the gas structure is such that the molecular weight or gravity will vary, it is more difficult to design a centrifugal unit which will economically and practically handle such changing densities with a minimum of attention and adjustment. On the other hand, the effect of changing molecular weight on a reciprocating unit will have no noticeable effect on compression horsepower except to increase or decrease the power lost in the valves.

There is no easy means of making cost comparisons between centrifugals and reciprocating compressors. Any comparison between the purchase costs of the equipment must be tempered within the evaluation of the installation, operational and maintenance charges assessed to each machine. In general, reciprocating machines are more efficient and cost less initially than a comparable centrifugal. However, the latter usually requires a smaller foundation and less floor area. Modern technology has kept maintenance costs low and availability high on both types of units.

Reciprocating Compressors



RECIPROCATING COMPRESSOR SPECIAL REPORT . . .

2. Mechanical Design—It's easier to select and operate a compressor if you know its design & characteristics.

T. O. Kulvinen
The Cooper-Bessemer Corporation
Mount Vernon, Ohio

THE RECIPROCATING compressor has been well established for a wide range of applications. Speeds may range from 125 to 514 revolutions per minute. Piston speeds range from 500 to 950 feet per minute, the majority being 700 to 850 feet per minute. The nominal gas velocity through valving is usually in the range of 4500 to 8000 feet per minute. Discharge pressures may range from vacuum pumps to 30,000 pounds per square inch.

The reciprocating compressor fundamentally is a fixed capacity machine with variable capacity obtained by altering the speed of the prime mover. Capacity may be varied on multiple cylinder machines by making head or outer ends and crank or inner ends inoperative by utilizing devices that lift suction valves open manually or automatically. Additional clearance volume may be provided, which can be cut in or cut out, to vary the compressor capacity as required.

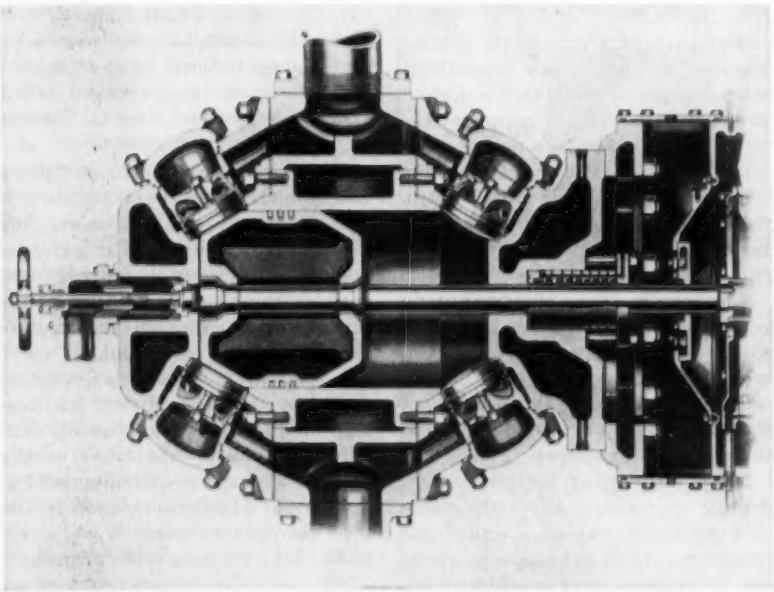


FIGURE 1—Compressor cylinder for medium pressure service. Multiple valves are used to keep clearance volume at a minimum.

For some applications, it is often desirable to include a large clearance volume to maintain approximately constant horsepower over a wide range of pressure conditions. Thus, economical operation is attained by operating the prime mover at its rated load for a broad range of operating pressures.

During design, all parts are given thorough stress analysis to determine that operating stresses are within the endurance strengths of the materials used. Adequate factors of safety are incorporated to cover expected variations in manufacture, materials, and customer usage of the compressor.

Many of these designs are fatigue tested by submitting the actual cylinder assembly to pulsing pressure supplied by a hydraulic pump. Tests were carried out in increments involving at least 6 million cycles of pressure pulses at each pressure until some part failed. From these tests the maximum allowable working pressure for a suitable factor of safety is determined.

Construction—Larger diameter lower pressure cylinders are usually constructed as shown in Figure 1. Pistons are of medium strength specification cast iron or of aluminum alloy. Either type are light construction with ribbing to maintain minimum reciprocating weight. Cylinder heads, cylinders, and cylinder liners are made of specification cast iron. Cylinder heads are fitted with multiple valves to keep clearance volume at a minimum. Piston rods are usually of medium carbon

steel. The area on which the packing runs is hardened for long wear life (usually by induction heating and water quenching).

Piston rings are usually cast iron but may be special bronze, multiple piece cast iron, or multiple piece thermosetting plastic. Selection of this material is based on the gas and the type of the compressor service. Piston rod packing is usually multi-stage metallic using materials similar to the piston rings. Practically all compressor cylinder manufacturers supply piston rod packing engineered and manufactured by specialists in that field.

Design—Suction and discharge valves cover a greater area of individuality in design than other parts of a compressor cylinder. In general multiple disc plate valves or strip valves seating on multiported cast iron seats are used. The valve plates open against very light springs in a valve guard. Narrow seating areas and light springs minimize pressure differentials required to open the valves, to keep compression work loss to an absolute minimum. Valves are held in place by cages and caps that in turn are restrained by a circle of studs or bolts.

The outer head of a compressor cylinder is usually equipped with an additional clearance volume chamber that becomes effective by manually opening a built-in valve. In this way clearance space of the outer compression space is altered to reduce the capacity. The volume is usually determined while engineering the compressor cylinder application. Compressor cylinders are sometimes fitted with a fixed clearance pocket cast right in the head. Sometimes a selective clearance volume bottle is attached to the head. Sometimes a variable volume, controlled by manual or hydraulic positioning of an auxiliary piston within the clearance chamber, is provided.

For services of around 1000 psi, a cylinder design as shown in Figure 2 is often used. The higher pressures naturally require heavier walls in the body and head castings. Valves are arranged at right angles to the main bore.

Cylinders as shown in Figure 2 are designed with greater built-in clearance. Added clearance is obtained by using the unique double deck valve construction. When pressure ratios are low, cylinders of this type (equipped with double deck valves

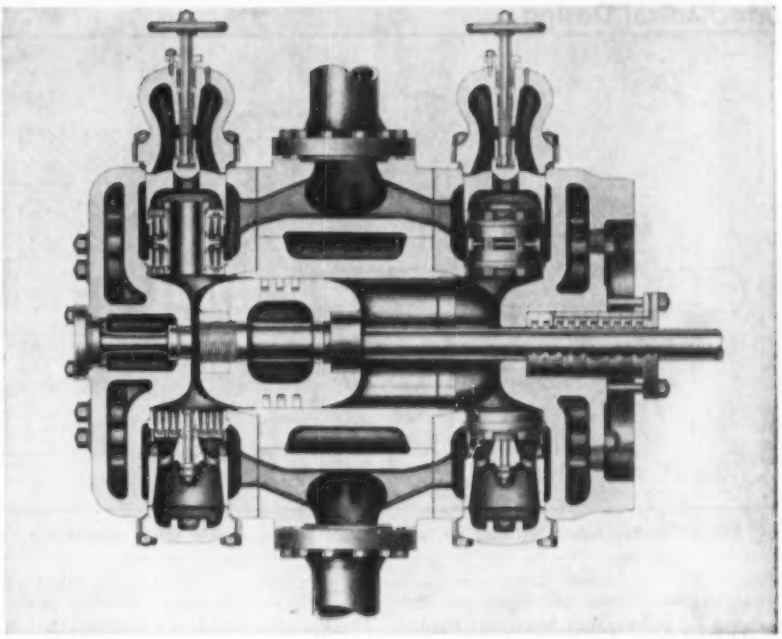


FIGURE 2—Compressor cylinder for 1000 to 1500 psi service. Heavy walls are required and valves are at right angles to the bore.

and large clearance volumes) are self unloading for a wide range of pressure variations. Thus the compressor driver remains at or near full load through a larger range of pressures and capacities with good economy in fuel consumption or motor efficiency.

For higher pressure service, the designer soon runs out of space for all components when he attempts the design with even the best grades of specification cast irons. A few years ago a new material, nodular iron, was developed that fills this need. Nodular iron is produced in the foundry similarly to high strength iron. Patented processing produces an iron having the free graphite uniformly distributed in spherical nodules. The nodular iron material is stronger since the notch effect caused by graphite flakes has been eliminated. Furthermore, nodular iron material is ductile.

Ductile iron's tensile strength compares with mild steel castings. Its ductility, though less than steel, runs from three to ten per cent elongation depending on whether the metal is

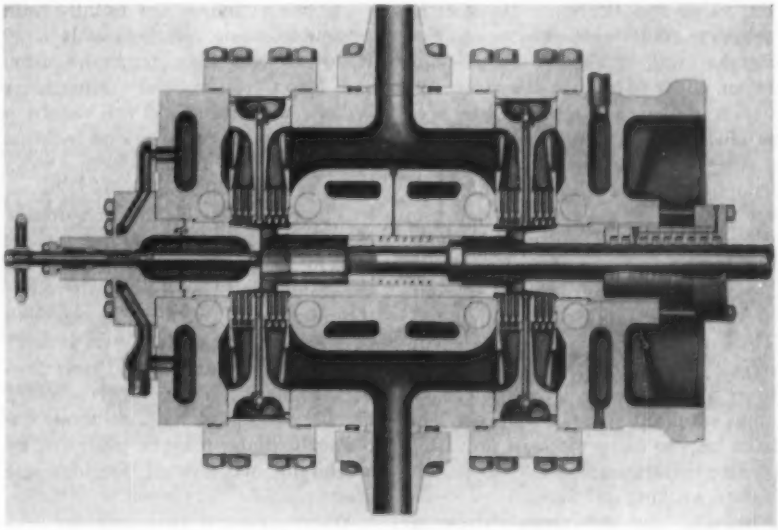


FIGURE 3—Compressor cylinder for 3500 psi service. Tie-in bolts help carry the load.

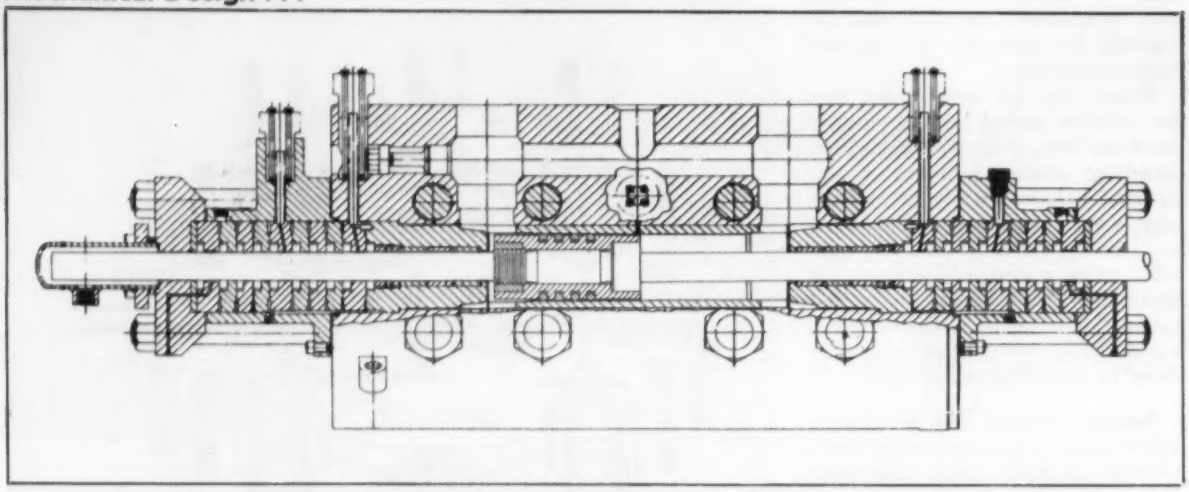


FIGURE 4—Recirculator cylinder for high pressure service. Double acting cylinder with a tail rod of the same diameter as the piston rod.

used in the as-cast condition or annealed by subsequent heat treatment. Many designs exactly like Figure 2 have been giving excellent service up to 1500 psi using nodular iron castings. The versatility of this new high strength ductile foundry product should continue to promote usage at even higher pressures as acceptance increases.

Steel castings are used quite universally in higher pressure cylinders. Since steel castings are more difficult to produce than iron castings compressor cylinder designs are limited to those employing fewer valves.

As the designer attempts to produce designs to withstand higher pressures he discoveres the maximum stress occurs at the junction of the bore for the valve and the main bore of the cylinder. As it becomes impossible to increase wall thickness at this point in an effort to reduce the stress, the design shown in Figure 3 has been produced. The cylinder body is a steel casting fitted with a shrunk in cast iron liner. Eight alloy steel tie bolts are installed at the junction points of valve pocket bores and cylinder bore. Controlled preset of these tie bolts at assembly places the material in compression stress at the junction point. Thus, the internal pressure, when in service, starts to stress the cylinder from a negative level so that maximum resultant stress is reduced. The bolts help to carry the load providing greater endurance strength to handle higher working pressures.

Suction and discharge valves, of heavier design for pressures involved, are mounted in the cylinder body. The cylinder heads are inserted within the body and firmly seated on metal ring gaskets by the cylinder head studs. Flat head gaskets are not suitable for the higher pressures. The usual clearance volume unloaders are provided when required.

Many of the high pressure chemical processes require recirculation in the system. This often means handling relatively small volumes at high pressures and extremely low pressure ratios. Single acting cylinders result in heavy bearing loads on the driving frame. Double acting cylinders also give high unbalance between the outer end and the inner end because the piston is hardly larger in diameter than the piston rod. As a result, recirculator cylinders are usually built as double acting cylinders with a tail rod of the same diameter as the piston rod. Extra crossheads are unnecessary because the piston and rod weight is low. The rod is easily guided by using bronze bushings in the inner and outer cylinder heads. Such a design is shown in Figure 4. Usually the pressures in this design are in the range where steel forgings are required in the cylinder body and in the heads. Steel forgings can be produced in materials of greater tensile and endurance strength than obtainable in steel castings. Higher cost, however, is involved because the shapes required in a compressor cylinder must be produced by machining when steel forgings are used.

When extreme pressures are encountered, the design choice of necessity becomes the single-acting plunger-type of cylinder. Special materials are involved to get plunger surfaces hard enough to endure packing pressure. Nitrided steels are most commonly used. Cylinders are forged steel with iron liners with extremely careful attention paid to design details in order to minimize stress concentrations. Special valve designs, usually operating in line with the cylinder axis, are required to endure the dense gas being handled. All parts are more heavily constructed, and many parts are made of very high strength steels.

Figure 5 shows a design for 15,000 psi service. The plunger attaches to a spherical seated aligning device driven from the driving gear crosshead. Without such an aligning means, it would be difficult to maintain the operation of the metallic packing that seals the plunger.

Many of the gases being compressed in various processes react with some of the materials ordinarily used in compressors. The engineering of such applications begins with consultation and determination of corrosive and other effects. Valves may be made of stainless steels, piston rods may be stainless steel coated or nitrided. Liners may be of special alloys like Ni-Resist iron. Piston rings and piston rod packings might be ordinary cast iron, bronze, thermosetting phenolic plastic, or babbit-faced iron. Sometimes it is necessary to plate gas passages with a suitable coating, but this is quite rare. The combination metallurgist-designer team is essential to solution of such special applications.

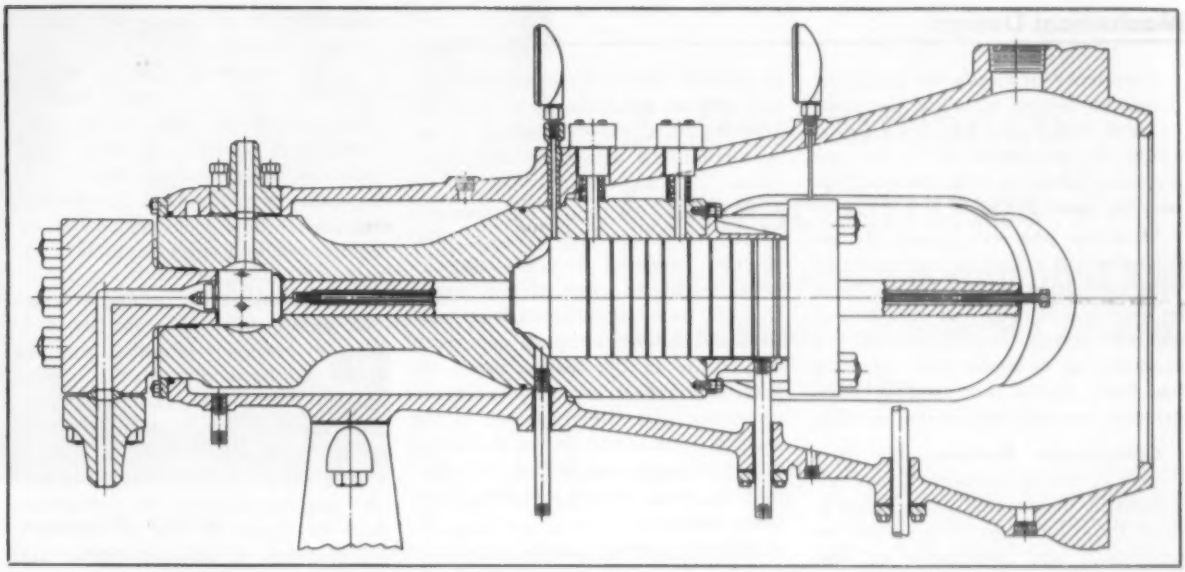


FIGURE 5—Single-acting cylinder for 15,000 psi service. Plunger attaches to a spherical seated aligning device.

Certain processes require the delivery of compressed gas or air that is absolutely devoid of any lubricant. If such is the case, it is often more expedient to construct the compressor for non-lubricated operation rather than attempt to deliver absolutely dry gas by extraction of lubricant carried over in the gas after compression.

The usual solution to this problem is to construct the piston of multiple disc spacers of dense fine grain graphite. Sectional piston rings, backed up by an expander spring, of the same type of graphite operate in the ring grooves formed between the piston pieces. The piston rod packing is also made of this same carbon material. Piston rods, hardened as usual, and cylinder liners are machined, ground, and honed to a very fine micro-finish. A very close grained iron is used for the cylinder liner.

Best wear life of carbon parts is attained when there is present in the gas a very slight amount of vapor. The well known platforming process is served with such designs as shown in Figure 6.

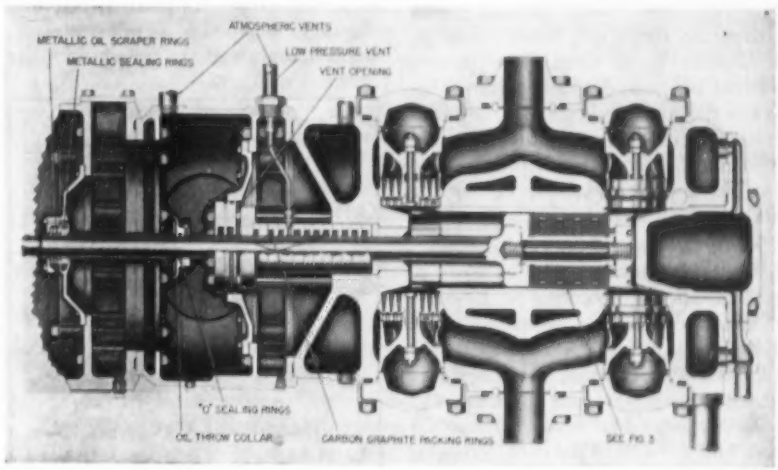


FIGURE 6—Non-lubricated compressor cylinder for moderate pressure. Best wear life of carbon parts if the gas has some vapor.

Lubrication—Reciprocating compressor cylinders are lubricated by the force feed mechanical lubricator. The lubricator is equipped with multiple units of individual plunger pumps with the unit having a built-in oil supply sump. A metered quantity of oil is forced into the cylinder at one or more points through check valves and to each packing as required. Such lubricators may be mechanically driven by the compressor or by an individual electric motor. The electric motor is more often used with motor-driven compressors to provide positive lubrication before the compressor motor is started.

Correct lubrication is vital to efficient operation of the compressor cylinder. In many cases the cylinders may be lubricated with the same oil as used to lubricate the engine or the compressor shaft and connecting rod bearings.

There are many cases where special consideration of lubrication problems is required. When the discharge temperature is high, the lubricant must have a high flash point when compressing air. Oxygen compressors must not use petroleum products nor vegetable oils for lubricants. Certain synthetic lubricants are suitable. When the compressor cylinder is handling gases carrying gasoline vapors or other condensible hydrocarbon vapors, a vegetable oil, or some combination of vegetable and petroleum oils may be used. A soap lubricant is sometimes recommended.

If gases are highly dehydrated, there

is a tendency to absorb the lubricant. A heavier bodied oil must, therefore, be used. Some gases have a chemical affinity for petroleum oil. In this case a special lubricant must be used, depending upon the gas.

In some processes, gases are involved which cannot be contaminated with lubricating oil. A lubricant must be used which, if carried into the gas, will not produce any ill effects. For example, an alcoholic soap lubricant has been found successful in compressing propane and carbon dioxide.

Compressor Drivers—The particular gas being compressed may not necessarily dictate the method used to drive the compressor. If the plant arrangement and availability of fuel dictates using an internal combustion engine, then compressor cylinders are generally integral as a part of an engine-compressor unit. Electric motor drives are frequently used. Some installations have available process steam; so, geared steam turbines become the logical choice. In the latter two cases, the compressor cylinders are attached to a compressor frame carrying its own crankshaft, connecting rods, and crossheads.

Quite a range of unit arrangements have been installed. These seem to run in all combinations from single cylinder compressor units to eight cylinder units and from one to six stages. The compressor manufacturers generally engineer each application to have an individual crank, connecting rod, and cross head for each compressor cylinder. Sometimes the best solution for multi-stage units requires placing some of the cylinders in tandem on a single connecting rod and crosshead.

It becomes apparent that the number of cranks, size of compressor pistons and phase relationship of multiple crank units influences the nature and magnitude of inertia forces resulting from the reciprocating motion. The compressor manufacturers keep these forces minimized by suitable arrangement of angles between the various cranks, by counterweighting, and by matching piston weights as near as possible.

Foundations—When engine-compressor units are installed, foundation requirements are controlled by the engine. A foundation designed as wide as possible and with sufficient mass will operate satisfactorily without excessive transmission of inertia forces to surrounding equipment and structures.

Reinforced concrete is the most universally used foundation construction. If the proposed location requires consideration of using friction piling, then the foundation construction must be carefully engineered to cope with the nature of the inertia forces involved. Piling structures must avoid resonance with the frequency of the reciprocating inertia forces and be of ample strength and suitable distribution to avoid forced vibration from these forces.

Motor or turbine driven compressor unit foundations are engineered to suit the compressor requirements. Breadth rather than depth is desired in the concrete mass. High foundations should be avoided so as to avoid rocking frequencies of the foundation that might be in resonance with inertia force frequencies.

A well enginered installation contributes greatly to successful long life performance of reciprocating compressors. A poorly engineered installation invariably results in many problems that preclude good performance no matter how well engineered the compressor unit itself might be.

Vibration—With multiple crank compressor units there are the problems of torsional vibration resulting from the harmonics of the varying pressures within the various compressor cylinders. The natural frequency of the compressor shafting may be controlled by suitable engineering of the coupling between the compressor and the driver. It can be controlled by selection of counterweights, and by adjustment of the mass of the driver or compressor pistons. The engineer correlates these factors to obtain a desired natural frequency to keep serious critical speeds removed from the operating speed range. Compromise enters the picture if the desired speed range conflicts with a feasible solution of the problem.

Along with the torsional vibration problem, it is necessary to investigate torque variation, caused by the compressor cylinder pressures, when motor drives or geared steam turbine drives are used. This must be done for all conditions of unloading.

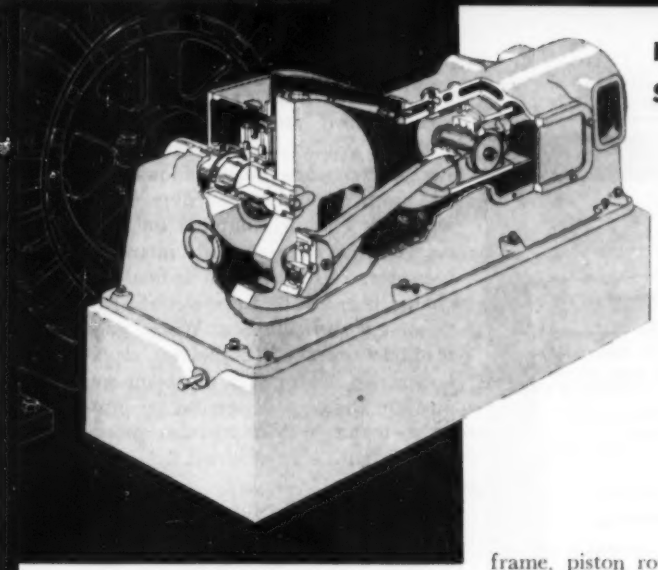
When alternating current motors are used as drivers, suitable WR^2 (flywheel effect) must be incorporated to keep current pulsation (caused by torque variation) within the tolerable limits established by motor manufacturers. Otherwise overheating and inefficient operation occurs. In the case of synchronous motors, the pulsation may be large enough to pull the motor out of synchronism and trip it off the line.

When geared turbine or other geared drives are used, torque variation resulting from compressor pressures or harmonics thereof may exceed the tolerance prescribed by the gear manufacturer. Excessive torque variation results in high tooth stresses and runs the risk of gear failure. Any torque reversal is intolerable because of gear tooth separation resulting in severe impact stress and impact noise. Short gear life in such cases is inevitable. High maintenance costs and unwanted down time are the penalties.

##

Meet the Author

THOMAS O. KUIVINEN, born in Ashtabula, Ohio, graduated from Ohio State University with a bachelors degree in mechanical engineering in 1929. Shortly after graduation, he was employed by The Cooper-Bessemer Corporation and since then his major activities have been in the fields of applied mechanics, design, and consultation. Ohio State conferred on him a professional degree of mechanical engineer in 1937. Then in 1939 he was assigned to the chief engineer's staff and in January, 1954 was made chief engineer, Technical Division. He is a member of the Society of Automotive Engineers and in 1954 was appointed an associate member of the executive committee of The Oil and Gas Power Division of The American Society of Mechanical Engineers.



RECIPROCATING COMPRESSOR SPECIAL REPORT . . .

3. Performance Characteristics—

Check this to be sure that the compressor will operate according to its design.

Howard M. Boteler
Worthington Corporation
Houston

THROUGHOUT the various branches of the petroleum and petrochemical industries one finds a great variety of reciprocating compressors performing a myriad of chores, each essential to the particular process to which applied. Some of the newer units may still be performing the jobs originally assigned them, operating under original contract conditions. Many others have been assigned new duties, some of them perhaps several times.

Frames and Cylinders—A reciprocating compressor consists essentially of a frame (or frames) to which are attached the necessary compressor cylinders and driver, plus the necessary auxiliaries such as intercoolers where required (either machine mounted or remotely located) interconnecting gas piping, jacket water piping, etc. Every compressor manufacturer has a group of standard frames, each having definite design limitations on speed and load carrying capacity. Load carrying capacity involves two considerations, namely horsepower and forces created by pressure differential across the pistons. The latter is generally referred to as frame load.

Horsepower limitations are determined by the ability of the crankshaft and crank webs (or crank discs) to withstand the necessary torque or turning effort without overstress, and by the ability of the bearings to dissipate the heat of frictional loading.

Frame load limitations are established to prevent the stresses in the frame, piston rods, connecting rods, bolting and other frame parts from exceeding safe conservative values, and to eliminate the imposition of excessive pressure per projected unit bearing area. Frame load for each compressor crank is equivalent to the sum of the differential loads of all pistons attached to that crank. The load for each piston is the difference in the products of net piston areas and pressures exerted on the piston faces. Loadings should be determined for both directions of piston movement. The loadings are not the same in each direction and where the ratio of piston rod area to piston area is high, they may be vastly different. An undesirable negative loading may sometimes result and provision must be made, such as a tail rod addition, to remove the unbalance.

Essential Information—Before a truly complete analysis of a compressor performance problem can be made certain essential data concerning the problem must be available. Such information must come from the prospective user in the inquiry. Figure 1 is an inquiry data sheet indicating facts which must be known for a full analysis. If the prospective user will furnish all of the information requested in this form, a much more intelligent analysis of the problem can be made than would otherwise be possible. A glance at the form will show numerous essential and revelant data. How essential the information is can perhaps best be realized by understanding how it is used.

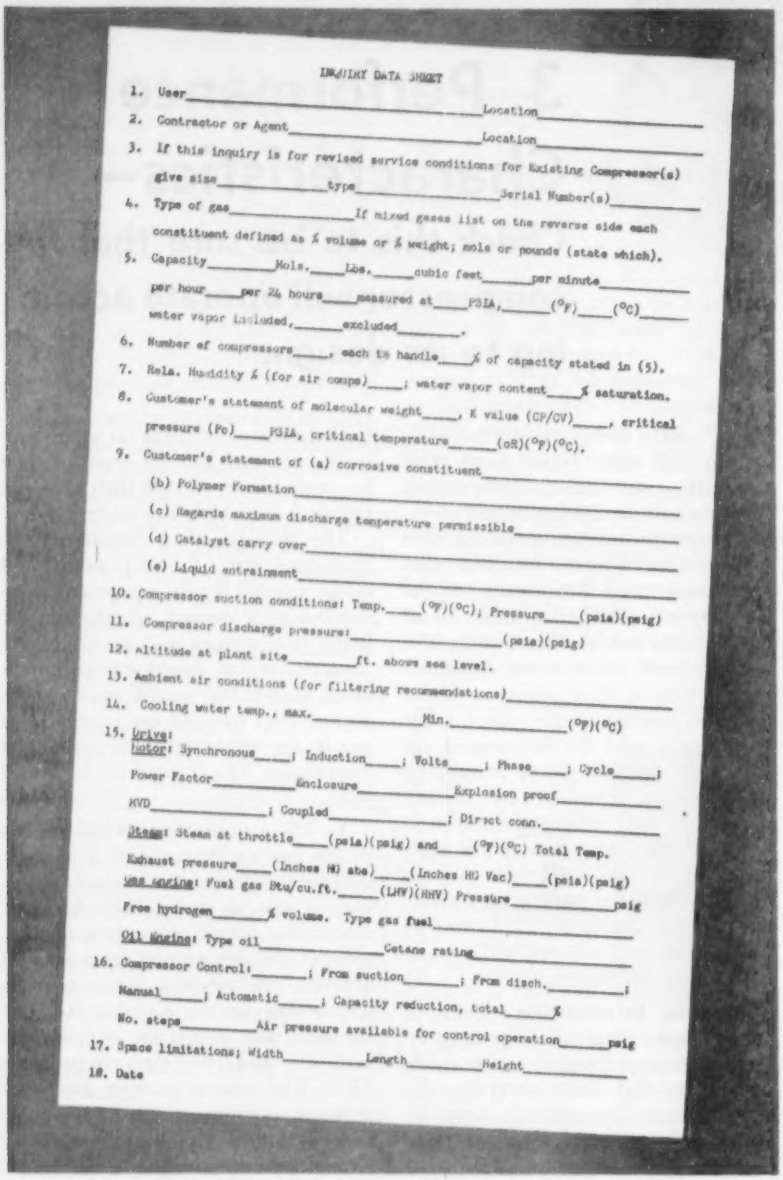
To better appreciate this, however, it is necessary to become familiar with certain terms and definitions used in the industry. Figure 2 sets forth the more common ones. These have perhaps appeared in print on many previous occasions, but are repeated here for convenience so that their true significance may be better understood.

The inquiry data determines the types and size of compressor and driver needed if new equipment is requested or if desired, whether an existing compressors and its driver are suitable for the stated service conditions. Or whether modification can be made to an existing machine to permit its use safely under the stipulated conditions. The procedure is briefly this:

1. The compression characteristics of the gas are determined. For single component gases the necessary information can be found in published tables. For mixed gases these characteristics are determined from the gas analysis. The physical constants to be determined are the K value (C_p/C_v) the molecular weight, the critical pressure (Pc) and the critical temperature (Tc). The critical pressure and temperature as determined from the analysis of mixed gases are sometimes termed pseudo-criticals.

2. The total ratio of compression is determined. This is the ratio of final absolute discharge pressure to absolute initial suction pressure. It must now be decided whether the compressor is to have 1, 2, 3 or more stages of compression. Experience will indicate quite readily how many are needed. The primary consideration is the expected discharge temperature. A sufficient number of stages, with cooling between them, must be used to prevent the discharge temperature of any of them exceeding practical limits.

Another consideration is the relationship of volumetric efficiency and ratio of compression. Gases having the



INQUIRY DATA SHEET

1. User_____Location_____
2. Contractor or Agent_____Location_____
3. If this inquiry is for revised service conditions for Existing Compressor(s) give size_____type_____Serial Number(s)_____
4. Type of gas_____If mixed gases list on the reverse side each constituent defined as % volume or % weight; mols or pounds (state which).
5. Capacity_____Mols._____Lbs._____cubic feet_____per minute_____ per hour_____per 24 hours_____measured at_____PSIA,_____(°F)_____(°C)_____ water vapor Included,_____excluded_____.
6. Number of compressors_____, each to handle_____% of capacity stated in (5).
7. Rela. Humidity % (for air comps)_____; water vapor content_____% saturation.
8. Customer's statement of molecular weight_____, K value (CP/CV)_____, critical pressure (Pc)_____PSIA, critical temperature_____(oR)(°F)(°C).
9. Customer's statement of (a) corrosive constituent_____
   (b) Polymer Formation_____
   (c) Regards maximum discharge temperature permissible_____
   (d) Catalyst carry over_____
   (e) Liquid entrainment_____
10. Compressor suction conditions: Temp._____(°F)(°C); Pressure_____(psia)(psig)
11. Compressor discharge pressure:_____(psia)(psig)
12. Altitude at plant site_____ft. above sea level.
13. Ambient air conditions (for filtering recommendations)_____
14. Cooling water temp., max._____Min._____(°F)(°C)
15. Drive:
    Motor: Synchronous_____; Induction_____; Volts_____; Phase_____; Cycle_____; Power Factor_____Enclosure_____Explosion proof_____ MVD_____; Coupled_____; Direct conn._____
    Steam: Steam at throttle_____(psia)(psig) and_____(°F)(°C) Total Temp. Exhaust pressure_____(Inches Hg) abs)_____(Inches HG Vac)_____(psia)(psig)
    Gas Engine: Fuel gas Btu/cu.ft._____(LHV)(HHV) Pressure_____psig Free hydrogen_____% volume. Type gas fuel_____
    Oil Engine: Type oil_____Cetane rating_____
16. Compressor Control:_____; From suction_____; From disch._____; Manual_____; Automatic_____; Capacity reduction, total_____% No. steps_____Air pressure available for control operation_____psig
17. Space limitations; Width_____Length_____Height_____
18. Date

FIGURE 1—Inquiry Data Sheet—List of facts to be determined for analysis of compressor performance.

higher K values will show a higher volumetric efficiency for the same cylinder clearance and ratio of compression than low K value gases. An extremely low volumetric efficiency for normal service is not desirable since an excessively larger cylinder is needed to obtain the desired capacity. This results in a heavy differential load (frame load) and may require a heavier frame than would otherwise be needed.

It is customary in the refinery and chemical process industries for the project engineer, for process reasons or otherwise, to establish the number of stages of compression, and for each, the suction pressure, suction temperature and discharge pressure with due consideration given to pressure drop and cooling between stages. If this information is not contained in the inquiry the manufacturer will ordinarily assume nearly equal ratios per stage to be satisfactory and will assume appropriate intercooler and inter-connecting piping pressure losses between stages. He will likewise assume suction temperatures for the second, third, etc. stages consistent with the available cooling water temperatures as shown in the inquiry.

This part of the procedure shows why it is essential that not only the suction pressure, but all interstage pressures, if given, as well as final discharge pressure be fully identified as either gage or absolute. Where gage readings are specified the feet elevation above sea level at the plant site must be known so that absolute pressures, mandatory in selection procedure, might be determined.

3. The required capacity per compressor is determined and is converted to cubic feet per minute at inlet conditions of the respective stages. The proper corrections for temperature, pressure and compressibility must be made. Where the desired capacity is stated as dry gas, the inlet volume of each stage must be increased by the ratio of the total absolute pressure to absolute partial pressure of the dry gas at stage inlet. This step of the procedure again emphasizes the necessity for clarity and completeness in the inquiry data. The desired capacity rate must be explicit and the conditions of pressure and temperature at which measured *must* be given.

4. A rough check is made to determine the horsepower required. For this purpose generalized charts are used. The factors involved are the total actual capacity of each stage (*cfm* at inlet), the ratio of compression per stage, the specific gravity and the K value (C_p/C_v) of the gas. Again this emphasizes the requirement for complete gas characteristics, clearly stated pressures, temperatures, and capacities.

The total horsepower required for the compressor (sum of horsepowers per stage) determines the required frame size. The kind of drive, whether steam, motor, gas, etc. as stated in the inquiry will dictate the type of frame best suited. There is usually an established length stroke and speed for the frame selected. However, for motor or steam turbine drive it may be necessary or advantageous to modify one or both to better match driver characteristics. Having established these details, the piston speed, which in feet per minute is equal to $\frac{\text{stroke in inches}}{12} \times 2 \times \text{rpm}$, as needed in Step 5, can be calculated.

TERMS AND DEFINITIONS

1. D = Piston displacement, expressed as cubic feet per minute, is equal to square feet of net piston area × length of stroke in feet × number of compression strokes per minute.
2. V_a = Actual capacity, cubic feet per minute, compressed and delivered, expressed at the conditions of total temperature and total pressure prevailing at compressor inlet.
3. VE = Volumetric Efficiency = $\frac{V_a}{D}$
4. THP = theoretical horsepower is the horsepower required to compress isentropically the gas delivered by the compressor through the specified pressure range. This is often referred to as the adiabatic horsepower.
5. CIHP = Compressor indicated horsepower is the actual work of compression developed in the compressor cylinder(s) as determined from the indicator card.
6. CE = Compression efficiency is the ratio of theoretical horsepower to compressor cylinder indicated horsepower = $\frac{THP}{CIHP}$
7. BHP = Brake horsepower is the measured horsepower input at the crank shaft.
8. SIHP = Steam indicator horsepower is the power developed in the steam cylinder(s) of an integral or coupled steam engine driven unit, as determined from the steam cylinder(s) indicator card, to perform the required gas compression duty.
9. ME = Mechanical efficiency is the ratio of compressor cylinder indicated horsepower to brake horsepower or to steam indicated horsepower = $\frac{CIHP}{BHP}$ or $\frac{CIHP}{SIHP}$
10. OE = Over-all efficiency is equal to (CE) × (ME) or $\frac{THP}{BHP}$ or $\frac{THP}{SIHP}$
11. P_s = Suction pressure, pounds/square in absolute.
12. T_s = Suction temperature, degrees Rankine = °F + 459.6.
13. P_d = Discharge pressure, pounds/square in absolute.
14. T_d = Discharge temperature, degrees Rankine = °F + 459.6.
15. R = Ratio of compression = P_d/P_s.
16. C_p = Specific heat at constant pressure is the number of BTU required to raise the temperature of 1 pound of perfect gaseous fluid one degree Fahrenheit, pressure remaining constant.
17. C_v = Specific heat at constant volume is the number of BTU required to raise the temperature of 1 pound of perfect gaseous fluid one degree Fahrenheit, volume remaining constant.
18. K = The ratio of specific heats = C_p/C_v.
19. T_c = Critical temperature is the temperature, degrees R, of a gas above which it cannot be liquefied.
20. P_c = Critical pressure and is the absolute pressure per square inch required to liquefy a gas at its critical temperature.
21. Pr = Reduced pressure is equal to P/P_c.
    Prs = Reduced pressure at suction pressure = P_s/P_c.
    Prd = Reduced pressure at discharge pressure = P_d/P_c.
22. Tr = Reduced temperature is equal to T/T_c.
    Trs = Reduced temperature at suction temperature = T_s/T_c.
    Trd = Reduced temperature at discharge temperature = T_d/T_c.
23. F = Compressibility factor which expresses the deviation from the perfect gas law. This is sometimes given the symbol "Z".
24. F_s = Compressibility factor at compressor inlet pressure and temperature.
25. F_d = Compressibility factor at compressor discharge pressure and temperature.
26. f = Ratio of compressibility factors = F_d/F_s.
27. C = Cylinder clearance volume and is the volume in one cylinder end in excess of the piston displacement per stroke. It is usually expressed as a percentage of stroke displacement.
28. TV = Terminal volume is the space occupied at discharge pressure and temperature of a unit volume of gas entering the cylinder at suction pressure and temperature.

FIGURE 2—Terms and definitions used in this article as applying to reciprocating compressors.

5. The approximate compressor cylinder sizes can now be determined. The required capacity of each has already been established (Step 3). From appropriate charts or formulae the volumetric efficiency of each stage of compression is developed. This involves the ratio of compression, the *K* value of the gas and the compressibility factors at inlet and discharge conditions. A trial selection must be made, assuming cylinder clearance, and the size and clearance readjusted to match cylinder patterns and/or designs available.

This procedure again emphasizes the requirement for exacting inquiry data. If facts for establishing critical constants are missing the cylinders could be sized incorrectly, sometimes appreciably.

6. The frame loadings can now be checked to be sure that all are within the design limits established for the selected frame. If all are too high a heavier frame must be used. If one of several are high it may be possible to readjust the ratios of compression to bring all loadings within the rating. Failing this, a heavier frame becomes necessary.

7. Assuming the frame requirements have been met, the selection, so far as stroke, speed, number of stages and sizes of cylinders is now complete. There remains one more detail —a more accurate check of the horsepower required. In Figure 2 will be noted the terms "compression efficiency" and "mechanical efficiency." In Step 4 generalized horsepower charts were used. Such charts are termed generalized because they are based on average values of mechanical and compression efficiencies. It should be emphasized here that it is impossible to include in any one horsepower chart, such as the widely used "bhp per million" chart, other than average values for these two factors. Therefore, after the selection has been made and all factors involved in determining the compression and mechanical efficiencies are known, the horsepower can be quite accurately established.

The selection is now complete with full performance characteristics known for the conditions of service for which selected.

Multiple Service—Quite often an inquiry will list one or more alternate service conditions, such as a range in suction pressure or discharge pressure or both. Or perhaps, operation on alternate gas streams may be desirable, where pressures and capacities may or may not be identical. In such cases the requirements must be analyzed and the selection based upon the most severe conditions. It may be necessary to select cylinder sizes for one service, to obtain the desired capacity, and to base frame selection on the alternate service because of high horsepower and/or frame loadings required by the alternate.

PERFORMANCE CALCULATIONS

The Indicator Card—Figure 3 lists some useful formulae used in compressor selection and performance calculations. From these formulae the variables involved can readily be seen.

Performance Characteristics . . .

PERFORMANCE FORMULAE RECIPROCATING COMPRESSORS

1. **Ratio of Compression** = $\frac{P_d}{P_s}$

2. **Theoretical Volumetric Efficiency** = $1.00 - \left(\frac{R^{\frac{1}{k}}}{f} - 1 \right) C$

3. **Theoretical Means Effective Pressure** = $\frac{KP_s}{K-1} \left(R^{\frac{k-1}{k}} - 1 \right)$

4. **Theoretical (isentropic) Horsepower** = $.004364 \times V_s \times (M.E.P.)$

5. **Theoretical Discharge Temperature** = $T_s \left(\frac{k-1}{R^k} \right)$

6. **Theoretical Terminal Volume Expressed as Percent of V_s** = $\frac{f}{\frac{1}{R^k}}$

Note: All pressures and temperatures are in obsolute units. For nomenclature refer to Figure 2.

FIGURE 3—Performance Formulae—Used to determine compressor characteristics.

The formulae given are all theoretical. Certain modification of results obtained must be made to arrive at actual results. For instance, the actual volumetric efficiency is always lower than that derived from the formula shown because allowance must be made for entrance losses due to wire drawing through the cylinder ports and valves and for increase in volume due to heating during the inlet period. In addition, compensation must be made for leakage past piston rings and cylinder valves and for packing vent losses. Obviously, leakage is primarily a function of pressure differential and type of cylinder construction. Non-lubricated cylinders (carbon piston rings, etc.) can be expected to develop greater slippage than those receiving lubrication, as the oil effectively seals surface contacts in most cases. However, also of importance is the type of gas being handled. Certain gases are simply harder to retain than others and the problem is closely connected with molecular weight and viscosity. There are no hard and fast compensating factor that can be given to cover all these variables. It is customary to allow 3 percentage points for wire drawing and heating entrance losses, so that 0.97 may be substituted in the formula for 1.00. Slippage losses may vary from 2 to probably a maximum of 5 percentage points for ordinary applications involving oil lubricated cylinders and from perhaps 4 to perhaps 10 percentage points for non-lubricated construction. Thus a more practical formula might be:

Volumetric Efficiency = $.97 - \left(\frac{R^{1/k}}{f} - 1 \right) C - L$, where L is the slippage loss just discussed.

A visual concept of volumetric efficiency can be had by reference to Figure 4. The indicator card shows what takes place within the compressor cylinder. The shape or appearance of the card varies with pressure conditions, cylinder clearance, gas characteristic and other factors.

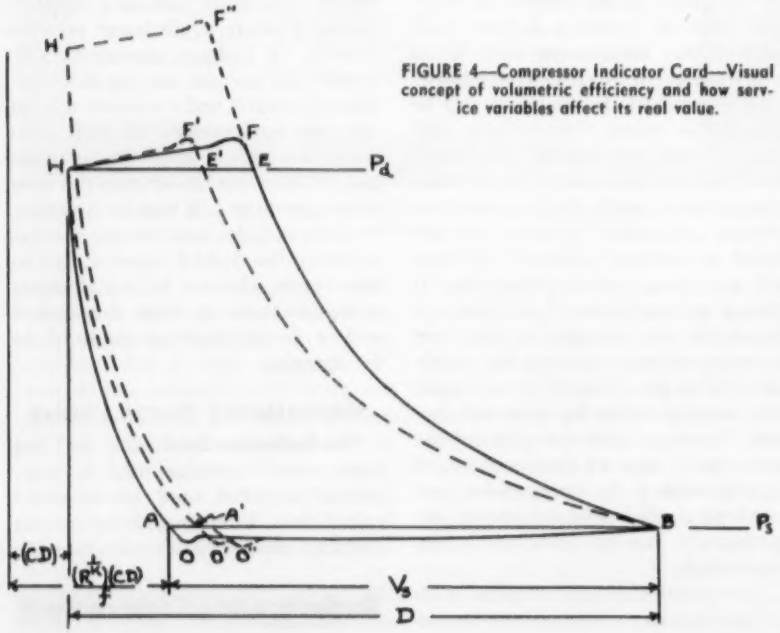


FIGURE 4—Compressor Indicator Card—Visual concept of volumetric efficiency and how service variables affect its real value.

In Figure 4, diagram ABEH represents behavior of a perfect gas under ideal conditions. P_s and P_d represent the suction and discharge pressures at the inlet and discharge flanges of the cylinder respectively. Movement of the piston from left to right represents the suction stroke. Point B represents the extreme point of piston travel on the suction stroke.

At B, the direction of piston travel is reversed and as the piston moves from right to left on the discharge stroke, compression of the gas trapped within the cylinder proceeds along line BE. At point E, pressure within the cylinder is equal to discharge pressure. Point E, therefore represents effortless opening of the discharge valve. From this point to the end of the discharge stroke at H, the discharge valve remains open while gas is being delivered to the discharge system.

It will be noted, however that some of the gas has been compressed into the clearance spaces within the cylinder and remains in the cylinder when the discharge valve closes. These clearance spaces are found between the valves and the piston, in the passageways in the valves themselves, in head cutouts under the valves for gas passages, linear clearance between the piston and head faces, etc.

As the piston reverses direction at H and again starts on the suction stroke, the gas at discharge pressure in the clearance space begins to expand. Volume increase and pressure reduction continue as the piston moves. Finally, the pressure in the

cylinder is equal to suction pressure, P_s, and the effortless suction valve opens at A, permitting the inflow of fresh gas for that portion, AB, of the suction stroke.

Since the displacement is a function of the length of stroke and since the length of the indicator card is proportional to the length of stroke, we can in the diagram, substitute displacement, D, for length of indicator diagram. We can also represent that portion AB of the suction stroke where in gas is flowing into the cylinder by V_s, the actual capacity at intake conditions. $\frac{V_s}{D}$, then is the apparent volumetric efficiency. The value indicated here is usually higher than the actual because the reduction caused by leakage loss is not fully effective at the point of valve opening. There is some leakage from the clearance spaces past the rings and suction valves, as the gas expands. This creates a faster than normal pressure decline and would tend to move point A to the left, for an apparent increase in volumetric efficiency. On the other hand, the expansion from H to A is not completely isentropic and therefore the temperature and volume are greater than theoretical. This slows the actual pressure drop and would tend to move point A to the right for a decrease in volumetric efficiency.

The increase in volume during the intake, AB, because of heat picked up by the gas, would slow the rate of flow from the suction system. In addition, leakage past the rings and valves during the discharge stroke reduces the volume delivered to the discharge system. Since the definition of actual capacity takes these losses into consideration, so must the volumetric efficiency. Further, the actual valve opening does not occur at A. The pressure in the cylinder must be sufficiently below the pressure at the inlet flange to overcome the effect of unbalanced valve area and initial spring resistance before the valve can open. The actual opening is, therefore at point O rather than at point A. Since none of these losses are reflected in the apparent or indicated volumetric efficiency, it is usually higher than the actual. The deviation will vary, however five percentage points might be considered the expected average.

The equation for theoretical volumetric efficiency shown in Figure 3 can be explained also by reference to the indicator diagram; Figure 4. For the expansion we can write the equation

$$\frac{P_1V_1}{T_1F_1} = \frac{P_2V_2}{T_2F_2}$$

Rearranging

$$V_2 = \frac{T_2F_2P_1V_1}{T_1F_1P_2}$$

Substituting subscripts d (Discharge) and s (Suction) for subscripts 1 and 2 respectively.

$$V_2 = \frac{T_sF_sP_dV_d}{T_dF_dP_s}$$

But:

$V_3 = V_{sc}$ = the volume of the clearance when expanded isentropically from pressure P_d to pressure P_s.

Also:

$$\frac{T_s}{T_d} = \frac{1}{R^{\frac{k-1}{k}}}$$

$$\frac{F_s}{F_d} = \frac{1}{f}$$

$$\frac{P_d}{P_s} = R$$

$$V_d = CD$$

Substituting:

$$V_{sc} = \frac{1}{R^{\frac{k-1}{k}}} \times \frac{1}{f} \times R \times CD = \frac{\left(R^{\frac{1}{k}}\right)(CD)}{f}$$

$$\text{Volumetric Efficiency} = \frac{V_s}{D}$$

$$\text{But } V_s = (D + CD) - \frac{(R^{1/k})(CD)}{f}$$

Substituting

$$\text{Volumetric Efficiency} = \frac{D + CD - \frac{(R^{1/k})(CD)}{f}}{D}$$

$$= 1 + C - \frac{(R^{1/k})(C)}{f} = 1 - \left(\frac{R^{1/k}}{f} - 1\right)C$$

Brake Horsepower—The theoretical horsepower naturally does not include fluid or mechanical friction losses. The fluid losses are grouped in the term Compression Efficiency while the mechanical ones are covered by the term Mechanical Efficiency.

The major factor involved in determining the compression efficiency is the valve loss or pressure drop through the inlet and discharge valves. These fluid losses are a function of gas density and valve velocity. The suction and discharge pressures and the molecular weight establish the density. The valve velocity is fixed by the valve area available in the selected cylinders and the piston speed. Valve velocity is normally stated in feet per minute and is the ratio of piston area to valve area per cylinder corner multiplied by the feet per minute piston speed. It is likewise equal to $\frac{144D}{A}$ where D is the piston displacement of one cylinder, in cubic feet per minute, and A is the valve area in square inches per cylinder corner. By valve area per corner is meant the area of the suction *or* the discharge valves in one end of the cylinder.

Valve losses are usually read from graphs plotted from research data. Applicable corrections for density are designated. There is at present, so far as is known, no precise general formula available for calculating these losses because of the numerous variables in valve designs in use, such as spring loadings, unbalanced areas and flow patterns.

A better understanding of the losses involved in compression efficiency may also be obtained by reference to the indicator diagram. If it were possible to get the gas into and out of the cylinder without fluid losses, the indicator card ABEH could be realized. This card may be said to represent the ideal or theoretical horsepower requirements. But fluid losses are present. Therefore the actual inlet pressure in the cylinder is below that at the cylinder inlet flange. Likewise the pressure in the cylinder during the delivery interval EH is above that at the cylinder discharge flange.

A more practical card would be AOBFH. Here the area AOB, fluid losses through the inlet ports and valves, and the area EFH fluid losses through the discharge valves and ports are included in the card area. Since the horsepower is proportional to the card area, the larger area by reason of fluid loss inclusion, means greater horsepower.

There are other considerations. During compression, BF, a small portion of the gas continually slips past the piston rings and suction valves. Work has been done on this gas, yet it is not delivered to the discharge system. Also slippage past the discharge valves allows gas which has already been delivered to the discharge system to return to the cylinder. Recompression and redelivery take place.

Unless leakage is abnormal the theoretical location of point E is not

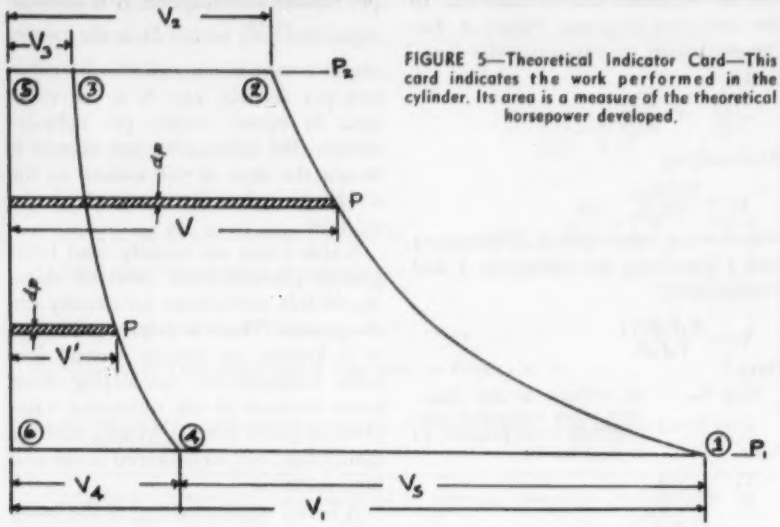


FIGURE 5—Theoretical Indicator Card—This card indicates the work performed in the cylinder. Its area is a measure of the theoretical horsepower developed.

greatly altered. Yet an over-all loss has occurred, first because more gas must be taken into the cylinder to compensate for piston ring and suction valve slip, secondly because work is performed on this lost capacity, and finally because leakages back through the discharge valves must be recompressed and redelivered to the discharge system.

There is still another factor, the cooling effect of cylinder jacketing. Removal of heat by the jacket water would shrink the volume during compression and would tend to move point F to the left reducing the power required. This is a true saving in power expended. Unfortunately it is not of any great significance, except in small cylinders handling rather low density gas through high ratios of compression where the jacket surface is large in proportion to the amount of work performed and heat generated. Further, cold jacket water should be avoided where the compressor is handling readily condensible gases which enter the cylinders at or near the dew point. In these cases it is actually desirable to superheat the gases during the inlet and early compression portions of the cycle, by hot jacket water, to prevent condensation within the cylinders. Condensation, liquid of any kind, and wet saturated gases are extremely detrimental to lubrication. In many cases the same factors adversely affect non-lubricated construction, especially valve service life.

The compression efficiency can be said to equal the ratio of the area of the theoretical card to that of the actual card, the actual card including the fluid entrance and exit losses as above outlined. A reasonable allowance must also be made for the slippage losses. These losses may ordinarily be considered as a reduction in compression efficiency equivalent to ½ to ¾ of the percentage point losses indicated in the volumetric efficiency formula. Again these losses must be predicated on experience and dictated by cylinder construction features, type of gas handled and operating conditions.

Horsepower Formula Development—The indicator diagram illustrates excellently the derivation of the formula shown herein for theoretical horsepower. To prevent confusion a second diagram for this purpose is shown in Figure 5. Path 1-2-5-6 is the compression cycle of a single stage compressor with zero clearance, while path 1-2-3-4 represents single stage compression with cylinder clearance. The energy represented by the area within the paths 1-2-3-4, compression with clearance, is the energy bounded by paths 1-2-5-6 minus the energy bounded by paths 3-5-6-4. This latter is the energy recovered from the expansion of the gas in the clearance space.

The energy of the zero clearance cycle is

$$\int_{P_1}^{P_2} V\,dp \quad \ldots\ldots (1)$$

The energy from expanding clearance gas is

$$\int_{P_1}^{P_2} V'\,dp \quad \ldots\ldots (2)$$

The net energy therefore $= \int_{P_1}^{P_2} V\,dp - \int_{P_1}^{P_2} V'\,dp$ ..... (3)

For isentropic compression and expansion

$P_1V_1^k = PV^k$ from which

$$V = P_1^{\frac{1}{k}}\ V_1\left(\frac{1}{P^{\frac{1}{k}}}\right) \quad \ldots\ldots (4)$$

and $V' = P_1^{\frac{1}{k}}\ V_4\left(\frac{1}{P^{\frac{1}{k}}}\right)$ ..... (5)

Substituting valves of V and V' from Equations 4 and 5 into Equation 3

$$\text{Net E} = P_1^{\frac{1}{k}} V_1 \int_{P_1}^{P_2} P^{-\frac{1}{k}}\,dp - P_1^{\frac{1}{k}} V_4 \int_{P_1}^{P_2} P^{-\frac{1}{k}}\,dp \quad \ldots\ldots (6)$$

$$= P_1^{\frac{1}{k}} V_1 \left[\frac{P^{\frac{k-1}{k}}}{\frac{k-1}{k}}\right]_{P_1}^{P_2} - P_1^{\frac{1}{k}} V_4 \times \left[\frac{P^{\frac{k-1}{k}}}{\frac{k-1}{k}}\right]_{P_1}^{P_2}$$

$$= \left(\frac{k}{k-1}\right)\left(P_1^{\frac{1}{k}} V_1\right)\left[P_2^{\frac{k-1}{k}} - P_1^{\frac{k-1}{k}}\right] - \left(\frac{k}{k-1}\right)\left(P_1^{\frac{1}{k}} V_4\right)\left[P_2^{\frac{k-1}{k}} - P_1^{\frac{k-1}{k}}\right]$$

$$= \left(\frac{k}{k-1}\right) P_1^{\frac{1}{k}}\left)\left(V_1 - V_4\right)\right.$$

$$\times\left[P_2^{\frac{k-1}{k}} - P_1^{\frac{k-1}{k}}\right] \quad \ldots\ldots (7)$$

But $(V_1 - V_4) = V_s$, which is the actual capacity, CFM, measured at intake conditions. Substituting $V_s = (V_1 - V_4)$ in Equation 7.

$$\text{Net E} = \left(\frac{k}{k-1}\right)\left(P_1^{\frac{1}{k}}\right)\left(V_s\right)\left[P_2^{\frac{k-1}{k}} - P_1^{\frac{k-1}{k}}\right] \quad \ldots\ldots (8)$$

Multiplying each side of equation 8 by

$$\frac{P_1^{\frac{k-1}{k}}}{P_1^{\frac{k-1}{k}}}$$

$$\text{Net Energy} = \left(\frac{k}{k-1}\right)\left(P_1 V_s\right)\left[\frac{P_2^{\frac{k-1}{k}}}{P_1^{\frac{k-1}{k}}} - 1\right] \quad \ldots\ldots (9)$$

But $\frac{P_2}{P_1} = R$: and substituting in Equation 9

Net Energy =

$$\left(\frac{k}{k-1}\right)\left(P_s V_s\right)\left(R^{\frac{k-1}{k}}-1\right) \quad \ldots\ldots(10)$$

The energy obtained from solving Equation 10 is in foot pounds per minute provided P is expressed as pounds per square foot absolute. Since in compressor work it is customary to use pounds per square inch as normal units, it is necessary to multiply by 144 and the energy formula then becomes:

$$W = 144\left(\frac{k}{k-1}\right)\left(P_s V_s\right)\left(R^{\frac{k-1}{k}}-1\right) \quad \ldots\ldots(11)$$

where

W = Foot pounds of energy per miinute.
K = C_p/C_v
P_s = P_s = PISA suction pressure
V_s = Actual capacity, CFM,/minute measured at inlet condition
R = Ratio of compression = $P_2/P_s = P_d/P_s$

The theoretical horsepower then becomes:

$$HP = \left(\frac{144}{33000}\right)\left(\frac{k}{k-1}\right)\left(P_s V_s\right) \times\left[R^{\frac{k-1}{k}}-1\right] \quad \ldots\ldots(12)$$

No attempt will be made here to explain the development of the horsepower formula including compressibility factors as it is felt that such is beyond the intended scope of this paper.

Variables of Performance—Volumetric Efficiency as represented by formula shown in Figure 3 and also by the relationship V_s/D, Figure 4, the indicator card, is obviously affected by:

(a) The cylinder clearance.
(b) The ratio of compressibility at discharge pressure and temperature to that at suction pressure and temperature.
(c) The K value of the gas being compressed.
(d) The ratio of compression.

By inspection of the formula it is noted that

(a-1) Increase in clearance lowers the volumetric efficiency. Thus it is common practice to use clearance pockets (additional clearance) to reduce capacities.
(b-1) Decrease in f lowers the volumetric efficiency. For perfect gases f = 1. For most hydrocarbon mixtures f < 1 while for certain diatonic gases especially hydrogen and nitrogen f > 1 under certain conditions of pressure and temperature.
(c-1) Decrease in K value lowers the volumetric efficiency. Thus, the volumetric efficiency of a compressor handling propane (K = 1.15) would be lower than were the same cylinder compressing hydrogen (K = 1.40).
(d-1) Increase in the ratio of compression lowers the volumetric efficiency.

A change in any of the above variables opposite to that indicated results in a higher volumetric.

The same phenomena can be visualized from the indicator card, figure 4.

(a-2) When clearance is increased there is more gas trapped in the clearance spaces. The numerical value of $\frac{(R^{1/k})(CD)}{f}$ is therefore increased and V_s, actual intake capacity is decreased as is V_s/D, the apparent volumetric efficiency. This would result in the expansion line taking some path, such as HA'O' resulting in delayed opening of the suction valves.

The compression line would be less steep and might be represented by BE'F'. The delivery interval F'H is also shorter. This is a further indication of reduced capacity.

(b-2) A decrease in f would have the same direction tendency upon the location of O and E as does an increase in clearance (a-2).
(c-2) Same tendency as (a-2) and (b-2).
(d-2) Here P_d would be higher than shown on the diagram or P_s would be lower, or both.

In either case the numerical value of $\frac{(R^{1/k})(CD)}{f}$ would increase. For instance if suction pressure remained constant and discharge pressure increased the compression would be carried to F''. Thus, a shorter delivery interval F''H' would prevail. Expansion of clearance gases would begin at H' and end at O''$_s$ where inlet would begin. Thus V_s, V_s/D and F''H' would be reduced below similar values prevailing at the lower P_d.

THEORETICAL HORSEPOWER as represented by the formula in Figure 3 and by the area of the indicator diagram Figure 5, is affected by

a) The suction pressure, P_s.
b) The capacity, V_s.
c) The K value of the gas.
d) Cylinder clearance.
e) The ratio of compression.
f) The ratio, f, of compressibility factors.

By reference to formula,

a) Other factors remaining constant the horsepower change is directly proportional to the change in suction pressure. For instance if the suction pressure is increased 50 percent the horsepower increases in the same proportion.
b) Other factors remaining constant the horsepower required changes in direct proportion to the change in V_s. For example if the capacity is reduced 50 percent, horsepower is likewise reduced 50 percent.
c) The variation brought about by change in K is three-fold. First, the capacity is altered. Secondly, the value of $\frac{K}{K-1}$ differs and thirdly, the value of $R^{\frac{k-1}{k}}-1$ changes. The net proportionate increase or decrease is the product of the ratio of altered to original values of the affected phrases in the formula. Suppose for example the K value change is such that V_s increases 5.13 percent. This would mean a corresponding decrease in $\frac{K}{K-1}$ of 33.3 percent but an increase in $R^{\frac{k-1}{k}}-1$ of 60.7 percent. The ratio of altered to original horsepower then is $1.0513 \times .667 \times 1.607 = 1.125$. Thus there is a net change of +12½ percent in power required.

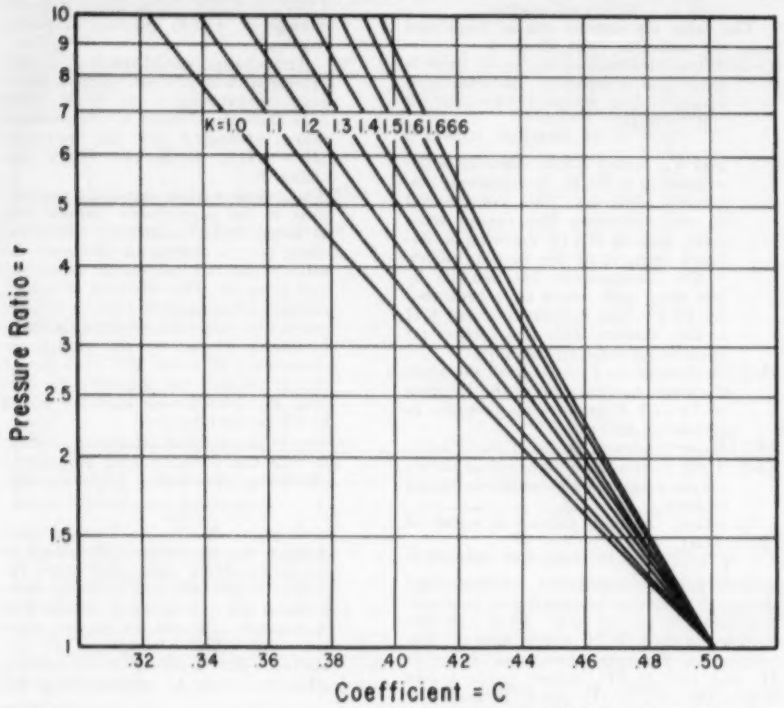
This change would result if a compressor with 10 percent cylinder clearance compressing a gas of K value 1.24 through 4 ratios of compression were changed to air service (K = 1.41), suction pressure unchanged.

d) The cylinder clearance does not appear in the horsepower formula but as noted under volumetric efficiency, item (a), a change in clearance results in altered volumetric efficiency and capacity. The effect of clearance change on horsepower is in direct proportion to the change in capacity brought about by the change in clearance. Should the clearance change reduce the capacity 25 percent the horsepower likewise would be 25 percent lower.
e) Should the ratio of compression vary, so will the capacity (see volumetric efficiency, item (d). Likewise, formula phrase $R^{\frac{k-1}{k}}-1$ would vary. Assume the compressors described in the preceding paragraph were required to operate at 5 ratios of compression instead of at 4 ratios. The K value is 1.24 and the suction pressure and cylinder clearance are unaltered. The decrease in volumetric efficiency would be approximately 8.0 percent. The change in $R^{\frac{k-1}{k}}-1$ would be an increase of 18.3 percent. The net change therefor would be $(.920 \times 1.183)$ or 8.8 percent increase in power required.
f) The effect of compressibility on the horsepower required per cubic foot capacity measured at intake conditions does not appear in the formula. It is small for average operating conditions. In high pressure units, however effects of sizeable proportions are sometimes found. For example, consider a cylinder handling carbon dioxide for a urea plant. Suction pressure is 1720 PSIA at 115 F. The discharge pressure is 3440 PSIA. From published data we find the critical pressure of carbon dioxide to be 1073 PSIA and the critical temperature to be 548° R. At suction conditions the reduced pressure, $Prs = \frac{1720}{1073} = 1.6$. The reduced temperature, $Trs = \frac{575}{548} = 1.05$. From a standard compressibility chart (1 psia basis), the compressibility factor, F_s, at intake conditions is .312.

The theoretical discharge temperature, using the formula from Figure 3, is 675 R(215 F.). Therefore, at discharge conditions of 3440 PSIA and 215 F.; $Prd = \frac{3440}{1073} = 3.2$. $Trd = \frac{675}{548} = 1.232$. Referring again to a standard compressibility chart, the compressibility factor, F_d, at discharge conditions = .575. Therefore $F_d/F_s = f = 1.842$.

Referring now to Figure 6 and following horizontally from a Ratio of

Performance Characteristics . . .



Procedure:

1. Determine compressibility factors F_1 and F_2 from compressibility charts
2. Calculate $f = \frac{F_2}{F_1}$
3. From given r and k determine coefficient (c) from this chart
4. Change in horsepower (deviation) = C (f — 1) HP (Ideal Isentropic HP)
5. Corrected horsepower is algebraic sum of Ideal BHP and deviation, Item 4 above.

FIGURE 6—Horsepower Deviation Coefficient.

Compression of 2, to the intersection with the diagonal line representing K = 1.3 (C_p/C_v for carbon dioxide) and reading vertically downward the coefficient "C" equal to .456 is found. Using the explanation given below the chart in this figure, the increase in theoretical horsepower will be C (f — 1) = .456 × 8.42 = .384 which means an increase of 38.4 percent in theoretical horsepower due to the effect of compressibility.

This example is probably one of the most dramatic which might have been selected but it has been used to exemplify the possibility of incurring overload unless all conditions surrounding the inquiry are known and evaluated. The converse is sometimes true and the driver may be appreciably underloaded. However, driver underload does not preclude operation whereas overload may. The possibilities must be checked to be reasonably certain. Compressibility factors are important.

Dirty Corrosive Gases and Wet Gases—The user should not hesitate to give the manufacturer a complete and frank statement of the expected qualities of the gas to be compressed. If the gases have a tendency to polymerize when subjected to normal discharge temperatures (250 F. to 350 F.) such fact should be made known. Additional stages of compression, beyond ordinary practice, may be needed. The user should attempt to give his version of temperature limitation to assist the manufacturer in his selection.

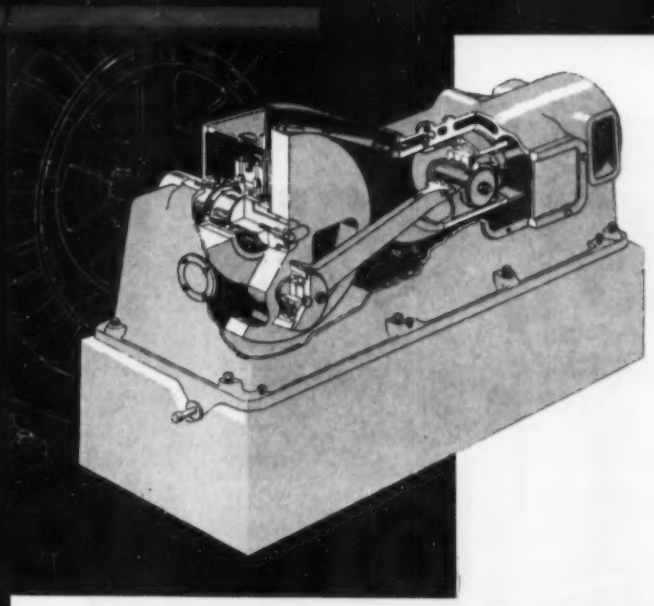
Every precaution should be taken to prevent catalyst dust, or dirt of any kind, entering the compressor. However, if previous experience indicates, regardless of practical safeguards used, that dust inclusion cannot be prevented this fact should be made known. While no one can guarantee 100 percent satisfactory compressor service under such conditions, yet a true statement and discussion of the facts could aid in the selection of more suitable and longer lasting materials for such adverse operating conditions.

The same might be said about corrosive constituents in the gases. Here the manufacturer's suggestions on predrying and preheating the inlet gas may prove invaluable. Likewise, provisions might be made in the cylinder jacketing to keep the gas dry while it is in the cylinder. Many troublesome corrosive problems have been cured in this manner.

Entrained liquid should never be permitted to enter a compressor cylinder. Neither should the jacketing arrangement and jacket temperature cause condensation within the cylinder. Adequate separators or scrubbers with reliable and positive drain features must be used before successful operation can be expected. This liquid removal equipment should be adjacent to the cylinder inlet to preclude post scrubber condensation. Once in the cylinder, readily condensable gases should be heated, rather than cooled, by the cylinder jackets. Hot jacket water is preferable to no water because its use does tend to maintain more uniform cylinder casting temperatures, thus minimizing distortion. A simple thermosyphon jacket system may suffice in many cases when provided with a coolant having a suitable boiling point. ##

Meet the Author

HOWARD M. BOTELER received a B.S. degree in mechanical engineering from the University of Maryland in 1923. He joined the Worthington Corporation that same year and spent several years in research and development, and field engineering. Two years later, Boteler was placed in charge of the research department, and two years after that was made manager of the Service and Erection department. In 1932, he was transferred to sales at Buffalo, N. Y. Here he was responsible for the application of reciprocating compressors for refrigeration cycles. In 1954, Boteler was transferred to Houston where he assumed his present position as engineering and sales consultant with respect to reciprocating compressor applications in the Southwest region.



RECIPROCATING COMPRESSOR SPECIAL REPORT . . .

4. Installation, Operation and Maintenance — These experience-proven tips will save costly errors.

Robert S. Ridgway
Standard Oil Company of California
Whittier, Calif.

PROPER INSTALLATION and handling of compressors is not acquired so much from a text as it is from experience. The sharp operator can profit considerably from the mistakes and experiences of others.

This discussion will be confined to the compressor only and not its prime mover except where the relationship cannot be disregarded. The article will also dwell lightly upon or omit entirely those things which are commonly accepted, and those installation practices which every manufacturer's service man will follow. Thus the presentation will be devoted principally to pointing out those things which are often omitted or neglected in many installations.

INSTALLATION

Selection of Site—The proper location for the installation involves such factors as safety, good soil, accessibility and proximity to cooling water. The compressor house location must be influenced by safety, particularly if the prime movers are internal combustion engines. Convenience to the gas being compressed, good soil for foundations, accessibility to a roadway for transport, and proximity to cooling water are influencing factors, although fuel and water for engines or electric power for motors can be brought to the site rather readily.

Foundations have a bearing upon the selection of the site. If new equipment is being installed, the foundation problem will probably be much less than with old equipment. Most manufacturers are giving more and more attention to balance of reciprocating machines, and care should be exercised when compressor equipment is being selected, to favor better balance. The site probably will be required to furnish a better foundation if gas engines are used for prime movers than if electric motors are supplied.

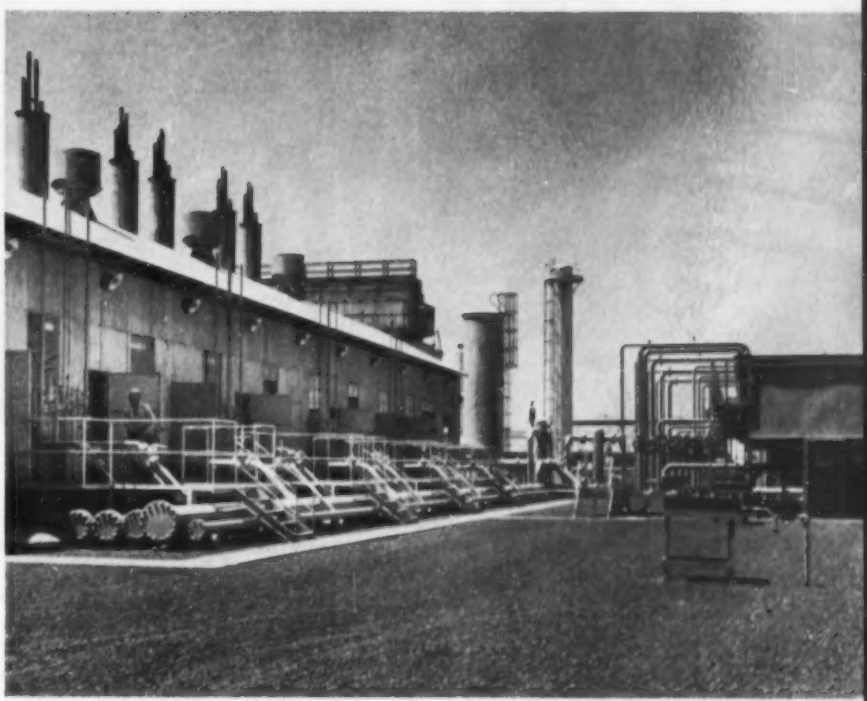


FIGURE 1—Gas headers outside bridged by separate walkway from each other.

Header Location—After the site has been selected the arrangement of plant and equipment must be planned. All of these items are so interrelated that it will be impossible to start with one factor and progress logically through the sequence of items involved in the plant. Piping will probably be the major factor at the site, the location of the headers being all important. This location must be planned with considerable care. It must be convenient to the area of gas supply, and provide ample room for the necessary scrubbers. Convenience seems to dictate running the headers parallel to the long axis of the plant (Figure 1). If pulsation dampeners are used, the tuned length

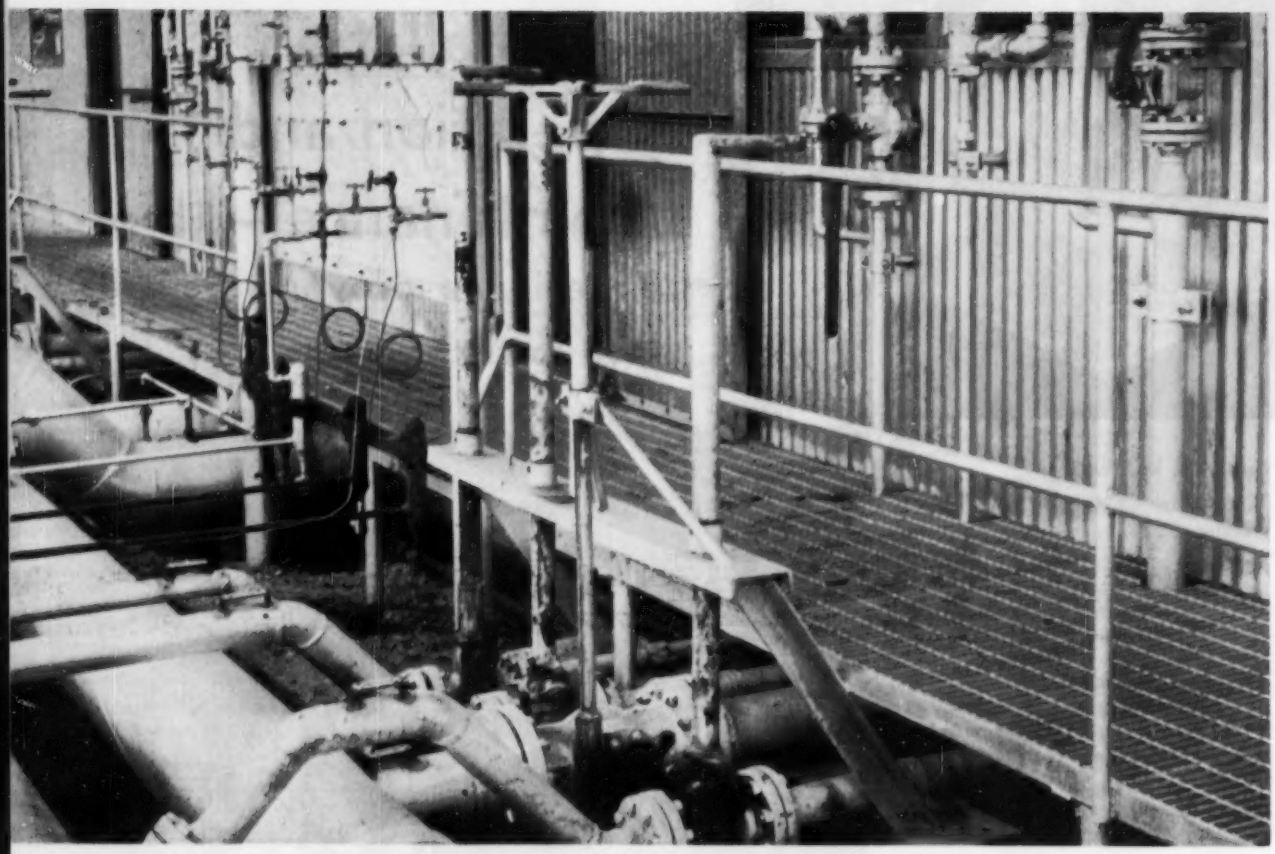


FIGURE 2—Longitudinal walkway for access to stop valves.

of the resistance tubes will frequently dictate a minimum distance out from the plant to the headers.

The gas headers were usually placed in a trench in the earlier plants, but more recently either the concrete trench has been eliminated entirely, or placed above grade so that drainage can be obtained. Height of the plant floor is thus dictated by the location of the headers, or by drainage of the subfloor under the gas surge chambers which are usually placed directly under the compressor cylinders, inasmuch as short connections between the cylinders and surge chambers are essential.

Arrangement of Units—The arrangement of units within the building is often the subject of considerable controversy. Engine-driven, direct-connected units are usually found to be most convenient when they are arranged with their crankshafts forming a single line, end to end. Occasionally to save space machines are set in a double row with the engine ends together, back to back. The compressor cylinders face the outside of the plant, and headers are run on both sides of the building. Operators usually regret this decision because the runway between engine sides is consequently narrow, dark and hot, and maintenance is difficult.

Some operators prefer to install their units crosswise of the plant, carrying the compressor piping to the building side in a trench. This arrangement was designed to permit crankshaft removal through the ends of the crankcase. However, such a design is questionable as shafts are never removed in many instances, and if this is ever necessary, such infrequent engine dismantling will not pay for the many other inconveniences. Where electric driven opposed compressors are used, with cylinders on both sides of the frame, setting the units with their crankshafts crosswise of the plant will be the preferred method. The piping from the cylinders on both sides of the unit can then be carried in basement trenches to the headers on one side of the building only.

Regardless of how the units are arranged, however, the principal item to remember is not to attempt to make a saving on the installation by skimping on the floor area, or getting the units too close together. On an eight-cylinder engine with a rail overhead, four pistons must be set on the space at each end of the engine during overhaul and worked upon, hence it will pay good dividends to allow plenty of room between units. Also, plenty of space should be allowed both in back of the machine for crankcase work, and on the compressor side for pulling pistons and rods.

Thought should be given during layout time for the possible addition of future units, whether or not it

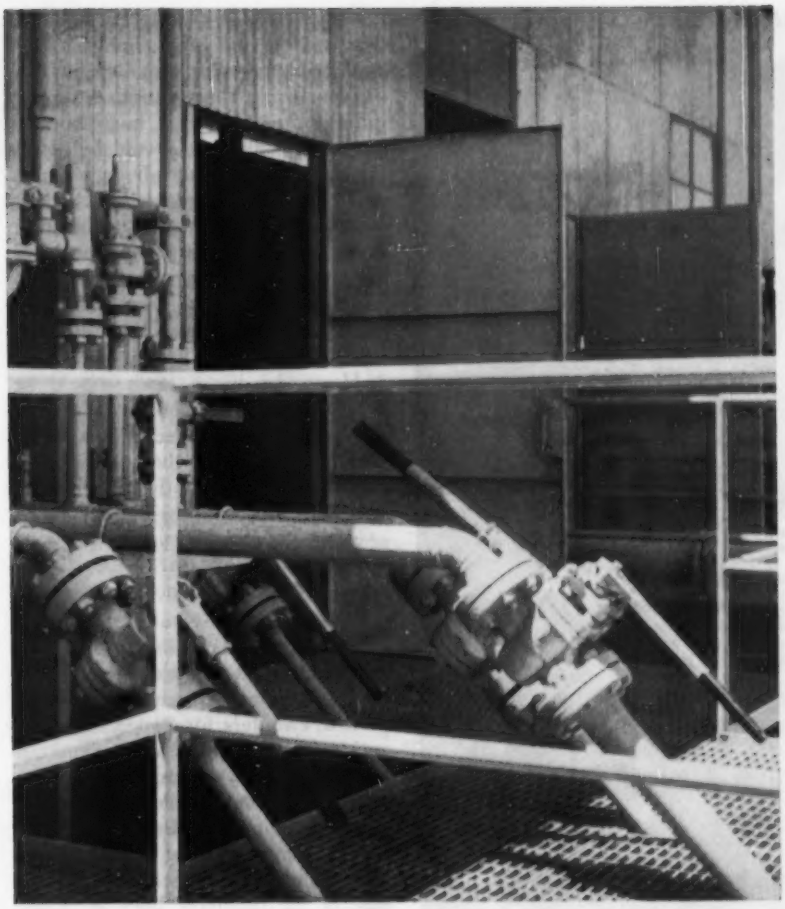


FIGURE 3—Novel method of installing high pressure stop valves. Safety valves securely anchored and very accessible.

seems unlikely at the outset. This must include space for the headers also. If auxiliaries are located in the building they must be either at the end where no expansion is contemplated, or in the center of the plant for easier access.

Compressor Building—Occasionally, in mild climates, someone will question the necessity of a building. This structure should never be omitted since, although rains may be infrequent, the water will find its way into the crankcases and distance pieces, and both rains and winds will seriously hamper the proper attention necessary for good operation and maintenance. Then, too, it is essential that a rail for a crane be placed over the compressor cylinders and another over the engine heads. Or a bridge crane can straddle the full width of the plant for only a slight increase in cost, and with much more usefulness. These can be incorporated into the structure. Care should be taken to see that the craneways extend through the end of the building for loading and unloading compressor equipment onto trucks.

The building should be well provided with windows for good lighting, as this will pay out in better maintenance and operation. Enough of the windows should open so that good ventilation is possible. Doors should be provided opposite each compressor for quick access to the valves located outside at the sides of the walkway.

It will be found much more satisfactory and convenient to make the floor of open grating wherever a trench or basement is underneath, rather than of floor plate. The grating is so much lighter that one man can remove it with ease, whereas floor plate is a back-breaker. Further, it has been found that the possibility of constant observation of surge chambers and piping underneath is quite advantageous. When this area is visible it never accumulates trash. The safety men should be called in to spot their fire protection in the early stages of design. An office, or room for records to be kept, also wash and change rooms, should be located as convenient to the building site as possible.

Piping—The compressor and service piping will constitute a major part of the installation. We have briefly noted the advisable location of the headers, but have not discussed their arrangement. Considerable study should be made of the header anchorages to care for stresses and thermal expansion of the lines. For this purpose piping contractors have developed pipe "hold downs" which permit either side or longitudinal deflection while restraining the other. These are used in conjunction with solid anchorages. Where side deflection of headers by lead-out lines will permit, solid anchorages can be installed near the center of each longitudinal header, and spring hold-downs may be used on either side. It is often advisable to "cold spring" headers and lead-out lines so that the minimum stress will be imposed when the lines are up to temperature. The pipe will expand .001 inches per inch for every 150 degrees of temperature rise, and this can add up to an appreciable distance in the length of a long compressor house. We note these items merely to call the reader's attention to the fact that this is a problem for an expert, and due recognition should be given to it.

The stop valves are normally placed in the lead-in and lead-out lines between the headers and the cylinder surge chambers, and these valves will usually be found to be most convenient when arranged close to the building wall. For access to them, a walkway is either run for the length of the building (Figure 2), or a platform and steps are provided opposite each compressor, with the valve extension handles being brought to the walkway railing. The safety valves should be located at an accessible spot close to the building so that their discharge lines can be carried individually above the building eaves. These vent lines must be quite firmly anchored if the valve is in high pressure service (Figure 3). When it is not possible to discharge the "pops"

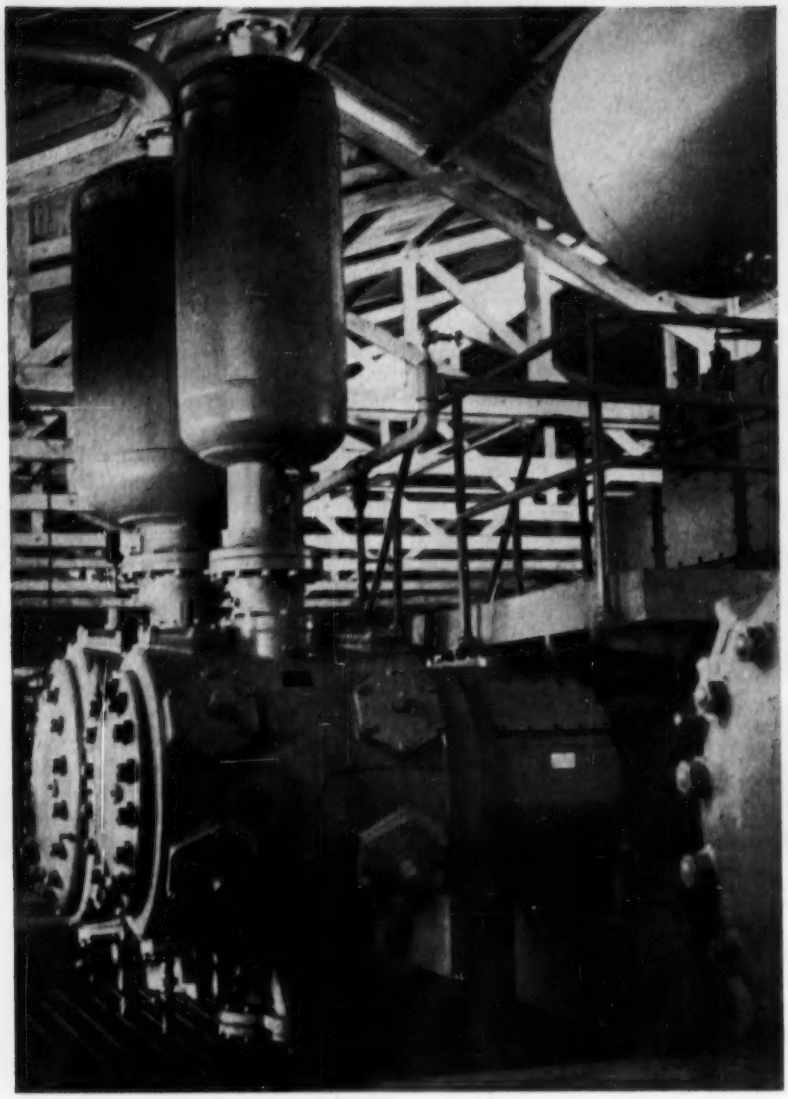


FIGURE 4—Vertical suction surge chambers.

in this manner, and vents must go to a common vent line, it must be amply sized for the worst possible condition.

Another point to watch in the compressor piping is the cylinder suction connections. Suction flanges are often rated at a lower working pressure than the discharge flanges on any cylinder, hence, with the compressor down, the suction stop valve closed, and the discharge open, that section of intake line between the stop valve and the cylinder can conceivably be subjected to discharge pressure by leakage of one suction and one discharge compressor valve. To protect against this possibility, a safety valve must be installed on the suction line, or the suction flange and piping must be adequate to safely handle the discharge pressure.

The point of having suction headers and piping extremely clean cannot be over-emphasized, as it will make so much difference in the amount of compressor valve trouble which will be encountered. Anyone who has experienced the incessant valve trouble caused by dirty lines will agree with the foregoing statement. We have found it wise to go to the extent of sand blasting all of the pipe used in fabricating headers, lead-in lines and surge chambers, and sealing them to protect against corrosion during construction. After the pipe work is completed, and just prior to startup, all lines should be blown down with 100 psig air in an adequate volume to give a good blow, with piping disconnected at the outer ends. If any of the piping or surge chambers have lain idle through inclement weather, they should be treated with great suspicion and thoroughly cleaned before using.

Heavy hardware cloth should be used to back up screen wire and made into steel ringed plates which can be inserted in the suction lines between flanges near the cylinders. In addition, screens should be placed over the compressor suction valves to remove all small particles. These screens should be removed after 2 or 3 weeks of operation.

Pulsation—Pulsation filters are commonly used today on suction and discharge lines adjacent to the compressor cylinders for two reasons: to remove disturbing pulsations from the plant pipe lines, and to prevent starvation and hence capacity loss in the case of the suction lines, and excessive pressures, resulting in high horsepower and some capacity loss, in the case of the discharge lines. Such filters are offered by several concerns and are readily obtainable. Some operators have been lucky about their pipe line pulsations and are still not sold on the advisability of installing filters. On high-pressure installations where the gas density is high, there seems to be no alternative, and the early installations without them usually experienced considerable trouble at the welded connections to the surge chambers.

If pulsation filters are to be omitted on either high or low pressure lines, then adequate surge chambers must be provided on both the suction and the discharge. The surge chambers will tend to prevent starvation of the cylinder on the suction side. There have been instances where cylinder capacity has been reduced by as much as 25 percent by operating without a suction surge chamber. Similarly, the discharge surge chamber will prevent excessive momentary discharge pressures which can result in severe overloads and also somewhat reduce cylinder capacities. These surge chambers may serve sev-

eral cylinders on the same machine. Their capacity must not be less than seven times the cylinder displacement (bore × stroke) for every cylinder served. They must be relatively close to the cylinder which they serve, else, in combination with the "gas jacket" around the cylinder, and the "too long" connecting line, they may constitute a filter themselves which may be improperly tuned, and some disturbing pulsations may result. However, don't let the fear of this unusual situation tend to favor omitting the surge chambers. Their omission will almost invariably cause shortage or overload conditions, even though it may not be recognized as such.

Discharge surge chambers normally are located on sleepers under the floor. Most high-pressure suction surge chambers are in a similar location for convenience in connecting to cylinder manifolds. Low-pressure suction surge chambers usually are placed across the top of the cylinders so that the cylinder connections can be extremely short. This also permits easy removal. Suction surge chambers may be placed vertically where space is limited (Figure 4). All surge chambers should be equipped with drains and pressure taps for checking pressure losses. Last but not least—don't place them where they cannot be removed for inspection or possible repair!

Scrubbers should be placed on all suction lines. These vessels should be equipped with a separating element to remove liquid, and should not be merely a "knockout drum." The latter does not do a satisfactory job of separating entrained vapor. Scrubbers should be equipped with a gage glass, automatic drain, high level alarm and a shut down device to shut the compressors down on high liquid level. Scrubbers should be located at an accessible spot convenient to the gas headers.

Unless the engines are supercharged, it may be wise to silence the air intakes to the scavenging cylinders of two cycle engines if noise is objectionable. This can be done with pulsation filters. It will be wise to locate the air intakes on such units at some distance from the building wall.

Unloading—On each compressor discharge (or for several cylinders in parallel on the same machine) a vent to atmosphere or a vent line should be provided for unloading. The safety valve usually discharges to this same vent. Unless some unusual situation demands that no gas be lost from the system, this type of unloading has some advantages over the bypass system. If, for any reason it cannot be used, then a bypass line and valve must connect the discharge to the intake, inside of the stop valves. Either system permits unloading during the startup and shutdown operations of the compressor.

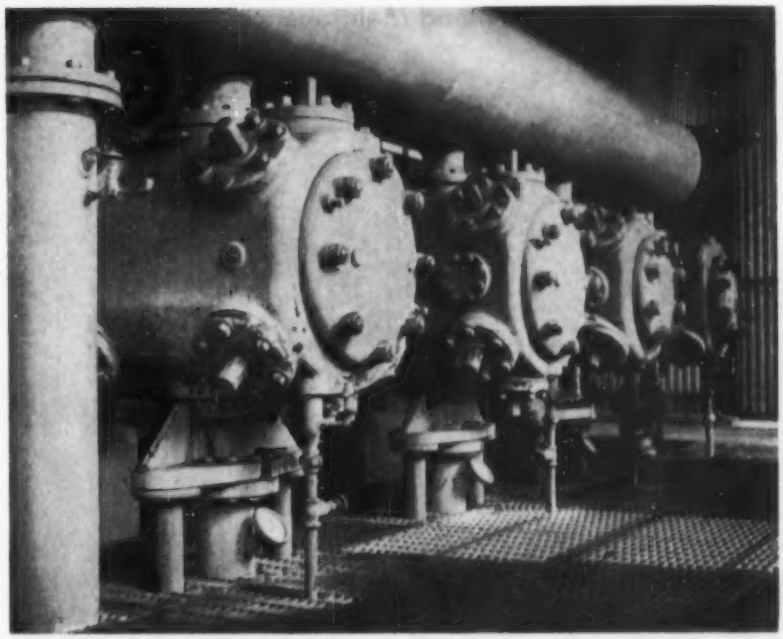


FIGURE 5—Special flange fitting below cylinders to permit cold supports.

Grout—In installing the compressor, the manufacturer will supply instructions for grouting and levelling, and they need not be repeated here. We would note, however, that if the crankcase is equipped with an oil pan or sump which projects below the rest of the crankcase, it is usually better not to grout around this pan. This can be worked out either by installing a piece of fiber board between the pan and foundation around the top rim, or placing a piece of fire hose around this section which is pressured with water during the grouting operation, then removed. The more recent practice of following the wet grout with a dry grout to prevent shrinkage has worked out excellently. Any wedges placed for levelling should be removed after 24 hours, else the frame will ride the wedges later on.

Cylinder Supports—The manufacturer will furnish full instructions on assembling the machine and installing cylinders. However, close attention should be paid to the method of supporting the compressor cylinders. It is imperative that the hot discharge line should not go downward to a rigid base, or base ell, which will result in an upward thrust on the cylinder when the line heats up. Cylinders are forced out of line, and occasionally distance pieces are cracked by such methods of installation. In earlier periods, the base ell was the standard method of supporting cylinders. They were usually held up by jackscrews, and manufacturer's service men were careful not to run these jackscrews down until after the discharge line had come up to temperature. Later, however, when the unit was down and cold, the fact that the jackscrews did not reach the support plate was usually noticed by some attentive mechanic, and the damage was done.

Customer pressure has caused the manufacturers to correct this trouble in various ways. Some have put lugs on the sides of the cylinders to which cast legs fit which support the cylin-

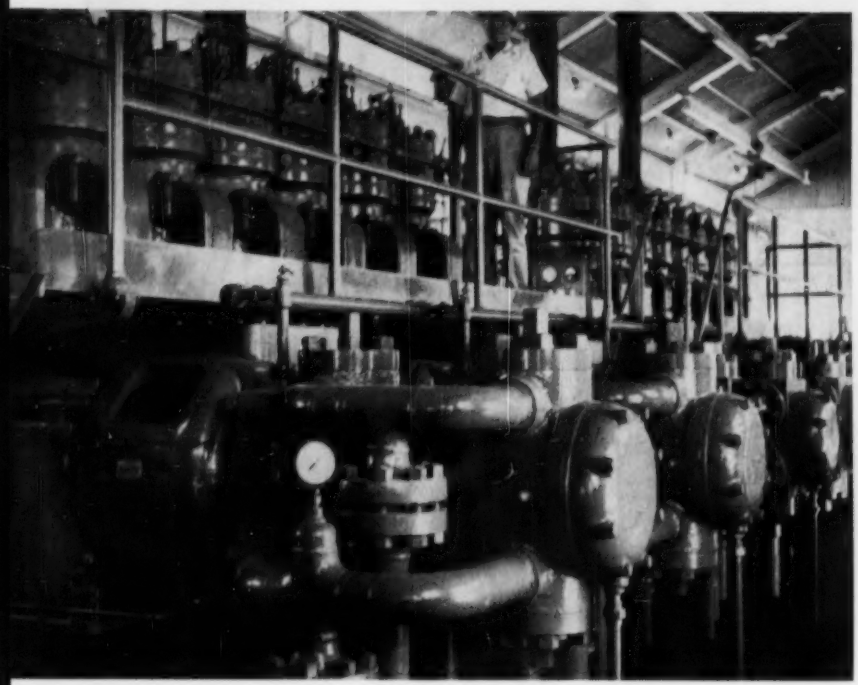


FIGURE 6—Method of locating thermometer in discharge line.

der, straddling the discharge trench. Others have made a wide flange fitting for the discharge, the projections on which are supported by 3-inch or 4-inch pipes which serve no other purpose but to support the cylinder, and are therefore always at room temperature (Figure 5). These methods serve the purpose excellently, but are completely nullified if the contractor fails to recognize the principles involved, and runs the discharge lines directly downward into base ells or surge chambers or any fittings which are rigid. Discharge lines should drop down into an ell which floats free and directs the line into a surge chamber. The ell can then bend under thermal stresses and relieve the cylinder of this strain. Within the last month we had occasion to look over a new installation where the contractor had defeated the provisions for good alignment provided by "cold supports" by installing rigid discharge spools directly into firmly anchored surge chambers directly below the cylinders on more than half of the units.

While on the subject of installation we would warn against the use of an impact wrench in running nuts. The impact wrench is very convenient when dismantling machines, but should never be used for setting up, due to the ease with which bolts and studs are overstressed. The new torque-limiting air wrenches are a different matter, and bid fair to combine a number of desirable qualities into one. Overstressing nuts has caused so much distortion in the past that we have found it wise to supply 1000 foot-pound torque wrenches for assembly of machine parts.

Jacket Water—In arranging to "service pipe" the jacket water, care should be taken to insure that the outlet water flows upward to the outlet header. If the outlet line from any cylinder drops downward it will form an air or gas trap which usually results in blocking off that cylinder, and diverting its cooling water through the others. If it becomes necessary to drop lines or headers downward prior to reaching the surge drum, then air expelling traps must be installed at all of these points to remove the gas which occurs whenever a gasket leaks, or the air which is sucked in by the centrifugal pump or trapped in the system after any dismantling. We have found it most convenient to install a vertical standpipe or surge drum of 20- or 24-inch pipe sufficiently high to collect all jacket waters, and provide an ample head for the centrifugal jacket-water pump. A permanent ladder is provided for this open top tank, and all outlet waters are directed into it at any elevation. The operators make a daily routine of climbing the ladder and checking the bubbles. This normally permits spotting gasket leaks and correcting them before they become serious. In piping the compressors it is good practice to install an industrial thermometer at each water outlet, both to be able to regulate the volume throughput, and to indicate trouble due to overheating.

Compressor manufacturers usually overestimate the heat rejection rate of the cylinder to the jacket water. Rates of 500 Btu per bhp-hr., and 175 times the ratio of compression are two of the most common factors supplied for this heat rejection. In our observation, both are considerably higher than any cylinder rejection rate we have noticed. In fact, it would seem that 100 times the compression ratio would be ample and much closer to the expected rate than the figures noted above. A few of the gas transmission line companies have installed cylinders with no water jackets at all, and put the major portion of the heat into the gas stream, radiating a small portion to the air. Such cylinders fit in well with their program, for normally the ratio of compressions on such stations is below 3. We know of instances where operators have filled the water jackets with oil and left the top openings unplugged. This equalizes the jacket temperature around the cylinder, but forces the rejected heat into the gas being compressed. It causes a small increase in the horsepower of compression, but could make the occasional gasket leaks difficult to find. Such practices are usually confined to ratios of compression below 3.

In water cooling the compressor cylinders, a temperature rise of 10 degrees will be found quite satisfactory. The temperature level may be kept around 120 to 130 degrees, and even higher if the gas is particularly wet, in order to prevent condensation in the cylinder and consequent high ring and wall wear. Such tempera-

tures are quite favorable to dry air cooling of the jacket water, particularly in high ambient temperatures.

Dial Thermometer—During installation, a minimum of instrumentation will include several items which are often omitted. Foremost of these is a heavy duty dial thermometer in each compressor discharge line, adjacent to the cylinder (Figure 6). This is for the purpose of supplying a ready index of the performance of the compressor valves and rings. Those who have not used such indicating thermometers have no idea of their usefulness in pointing out the situation when valves are going bad or valve gaskets are beginning to leak. This is particularly valuable on high pressure cylinders where valve or gasket leaks for only a short period of time either damage the valve beyond repair, or make the repair difficult. Similarly, when cylinder gasket recesses become slotted by high-pressure gas blowing through, it is a long and tedious job resurfacing them. A slight increase in temperature indicates trouble long before such trouble can be detected by the feel of the valve covers, and operators are usually enthusiastic about such a "trouble detector." A heavy duty dial thermometer without gears should be used to prevent destruction from vibration. Such equipment stands up well in this service.

The metallic packer should also be equipped with a thermometer to indicate its performance. If the manufacturer has not done so, the packer flange should be drilled and tapped, radially, for the installation of either a dial thermometer, or the bulb for a remote indicating instrument. The latter is required if the gas being compressed is poisonous, requiring the distance piece to be normally closed. This makes a very neat and convenient installation, as the temperature gages may all be mounted together on a single instrument panel, and any packer trouble will be pointed out rather forcefully. There have been instances where we have placed two such tapped wells in the packer flange and have placed a thermally-operated engine shut-down device in the second one. Such installations are for plants which operate unattended and we do not care to burn up the packer and ruin the piston rod in the event of packer trouble. We have seen instances where other operators have provided such protection in attended plants.

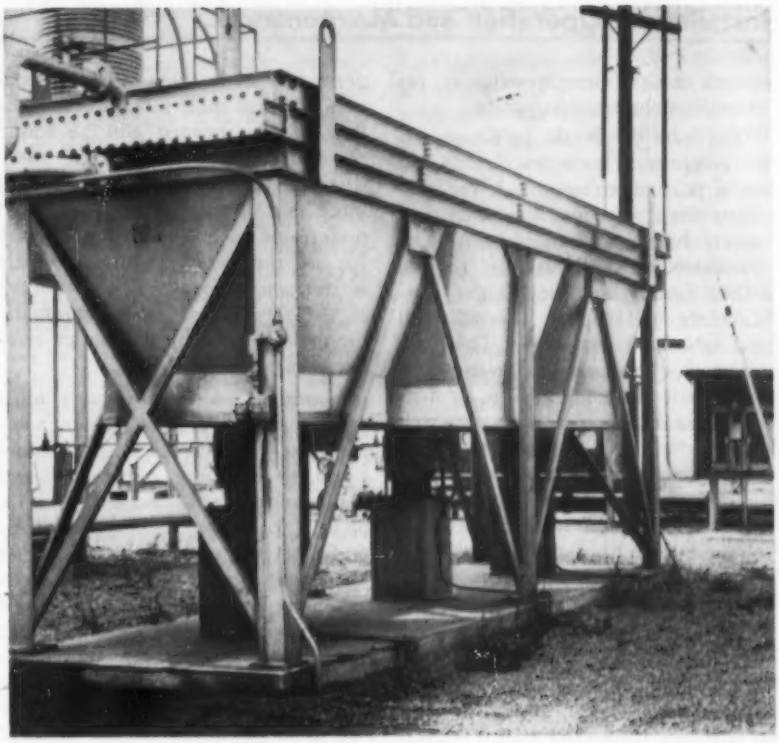


FIGURE 7—Single section three-fan unit for cooling jacket water.

Packers—While on the subject of packers, it has proven quite profitable to install a grease gun fitting and check valve on a tee fitting to the oil line leading to the inner lubrication point on the packer. This is for the purpose of breaking-in a new packer. During startup the grease gun can be filled with a heavy oil, and supplementary injections should be made frequently until both the thermometer in the packer flange and lack of audible blow-by indicate that the packer is seating properly.

Double acting wipers should always be used around the piston rod. Originally, single acting wipers were installed with the thought of stripping the crankcase oil from the rod which had splashed onto it, and preventing its loss to the distance piece. Occasionally, however, a heavier oil than is used in the crankcase, or an oil compounded with tallow is used on the rod, and when this oil is carried into the crankcase it results in contamination, causing frequent crankcase changes. On an electrically-driven machine, crankcase oil changes will be very infrequent unless contamination occurs.

Unless a poisonous gas is being handled, the distance piece covers should be left off on the "operating" side, so that operators can see the packer and its thermometer at a glance, and feel the rod. Recently the author had occasion to work with a gas dangerously high in hydrogen sulfide, and the covers were left on. This method of operation proved so unsatisfactory that the covers were left attached by one bolt, but were rolled out of the way. They could be rolled back into place if necessary in a moment. Any slight leakage was carried away by the vent lines which were tied into a vacuum collecting system. This method of operation proved quite satisfactory, and the thermometers were an excellent index for the operation of the packers.

Lubrication—When ordering lubricators it is possible to have them broken up into several compartments, usually at no extra cost. This may be found of great convenience at a later date if it is advantageous to

use oils of a different specification for the various lubrication points.

The lube oil should be filtered. If the compressor is electric driven and not a part of an engine driven machine, then an edge type filter will usually fulfill this requirement. The crankcase oil will usually require a little cooling, and for this the manufacturer will supply a small shell and tube heat exchanger. This may not always be economical to use, particularly if the cooling is to be furnished by dry air coolers. It may well require the jacket water to be cooled cooler than necessary in order to provide the temperature gradient to bring the oil temperature down to the required level, thus calling for more heat exchange surface in the jacket cooler than is necessary.

Therefore the possibility of cooling the oil directly in extended surface coils in the dry air cooler should be explored. This is far more attractive in a direct connected engine driven machine than it is in a compressor only, as there is so much more heat to extract in the former. Crankcase oil temperatures in the order of 150-160 degrees are usually quite acceptable. High oil temperatures are to be avoided principally because of bearing fatigue, the strength of the babbitt decreasing at the fourth power of the temperature. This usually becomes a temperature limiting factor ahead of any destruction to the lubricating oil.

A low oil pressure shutdown switch should always be used to save the bearings and sometimes the shaft in the event of an oil pump failure.

Intercooling—Gas intercooling can be done in shell and tube exchangers near the compressors, or in atmospheric sections placed in a cooling tower, or in dry air coolers with extended surface tubing where the air is circulated by fans. The choice depends upon the individual situation, the availability of cold water, or unused space in a cooling tower.

Dry air coolers are becoming more and more widely used for the ease of installation and the low maintenance involved, also for the simplicity of temperature control. Another factor to be remembered is that they give their full salvage value when it is desired to move them to a new location. Vertical shaft fans directing the flow of air upward will be found more satisfactory, as these are insensitive to wind direction. A number of small fans in parallel will be found preferrable to one large fan (Figure 7), as this will permit automatic startup and shutdown of one or more of the fans by providing automatic thermal control on the outlet temperature of the gas.

Inasmuch as design factors must provide for the highest ambient temperature expected, such control will prove to be quite economical and satisfactory. If the installation is to be near the ocean, copper fins will be preferred over aluminum. The jacket water and lube oil sections can comprise one unit with the oil sections placed beneath or beside the water sections. If the sections have been designed properly using the proper factors, the outlet temperatures of the two will follow each other roughly together as the ambient goes up or down, hence the control point for shutting down the fan motors may be placed in the water outlets, and the oil should never wander too far from the rather wide limits which are acceptable.

OPERATION

Starting—For the initial startup of the plant the procedure is, of course, quite different and more cautious than subsequent ones. After making sure that the compressor crankcase is extremely clean, fill it with lube oil, usually an SAE 30 grade, and pump oil to the pressure system with the hand pump which the manufacturer usually provides on such machines, both to make sure that the bearings are flooded and that the lines are free of air. Through the valve holes and with the piston backed out of the way, watch the oil holes in the cylinder walls while the lubricator is being hand cranked to insure that the oil comes freely and that all the air has been expelled from the lines. The assembly shoulld be once again checked over to make sure that the compressor pistons have been spaced properly (usually with ⅓ of the clearance on the frame end and ⅔ on the head end to provide for expansion of the rod).

Be positive that the compressor valves have been installed properly. Many compressor valves are interchangeable between suction and discharge, hence it is easy for the helper to get the valve in backwards. As there is no safety valve which will protect the cylinder from reversed discharge valves, a nice longitudinal crack usually reveals this error. Check the inlet valve screens and make sure that the valve covers have been pulled down evenly (a torque wrench is preferred) with the jackscrew loose when this is done. Then run the jackscrew down firmly onto the crab or guard to hold the valve tight onto its seat.

Check all the lines through the plant to insure against any closed valves or flange blinds, start the jacket water through the cylinder, check the safety shut-down and overspeed trip for their proper position, make sure that suction and discharge stop valves are closed and that the bleeder or bypass is open, and the unit should be ready for starting.

The unit should be run for not over two minutes, and careful attention should be paid to listening for knocks. During this period the lubricator, set to a heavy feed, should be checked. The unit should then be shut down, the covers removed and all the bearings carefully checked for excessive temperature. This procedure should be repeated for 5- then 10-then 30-minute intervals, after which, if nothing abnormal is apparent, the unit may be idled for several hours. During this time the packers should be watched and frequent gun injections of oil pumped into the packers. In starts after the first one, the unit should be idled for around ten minutes to permit the oil and parts to attain a running temperature before the load is applied. Whether it is initial or subsequent startups, the load is applied to the high pressure cylinders first in most multi-stage plants, dropping down in pressure to the low cylinders which puts all stages on the line before the main stream is brought into the system.

If the cylinder is equipped with a bleeder on the discharge, the load is applied by first cracking the discharge valve until the gas backing through it can be heard whistling through the vent line. It is then safe to close the vent and immediately

open the discharge valve fully. If a bypass is used, it is closed before the discharge stop valve is opened to keep the intake safety valve from popping. If the working pressure of the suction piping adjacent to the cylinder is higher than the discharge pressure, then the opening of the discharge may be completed, if desired, before the bypass is closed. The load is applied by gradually opening the intake valve.

In this connection it is often wise to compute the rod load when the cylinder is pumping against discharge pressure with atmospheric pressure on the intake. In rare instances this will be above the allowable, and, although this is usually not something to be too concerned about, due to the generous factors of safety provided by the manufacturer, the condition should not be permitted to exist for any period longer than is necessary.

For the compressor alone, or if it is electric motor driven, we see no advantage to be gained by applying the load a little at a time, such as is recommended for engine driven machines. Full load can be placed on a new cylinder whenever the running gear has shown itself to be in operable shape and has worn itself in for a few hours. When the unit is engine driven, the startup of a new machine should be entirely different beyond the points covered in the foregoing, for the sake of the new engine. Although this is a treatise on compressors, and not engines, we shall note such a startup briefly, inasmuch as the two are so closely interrelated. It has been the custom to start such engine-driven machines, after their running gear was proved, by operating several hours at ¼ load, several hours at ½, several more at ¾ load, then to apply the full load. This is principally for the benefit of seating the engine piston rings. Discussions with ring engineers have indicated that they would prefer to see such rings seated by short applications of full load, rather than continued applications of part load. For example, two 10-minute applications of full load with 15-minute intervals between for cooling, followed by two 20-minute applications of load interspersed with the same quarter hour idle intervals, and so on, seem to be preferred. Actual trial of this type of break in for the engine piston rings has worked out quite well.

Stopping—In shutting down, the cycle is reversed. The suction stop valve is closed first, followed by the closing of the discharge, as simultaneously as possible with the opening of the vent. If the two cannot be worked together, completely close the discharge first, then open the vent. In the event the suction was not closed properly, the discharge safety valve will pop. If a bypass is used instead of a vent the same procedure can be used, substituting the bypass instead of the vent in the above text.

If the suction piping and flanges are designed to stand the discharge pressure, then the bypass may be opened at will after the suction is closed and before the discharge is closed. If, however, the suction piping is rated at a lower working pressure and is protected with a safety valve, then the bypass should not be opened until the discharge stop valve is closed, else the suction safety valve will open. Although there is nothing wrong with this safety valve opening, it is a nuisance.

If the compressor is electric motor driven, the machine may be shut down as soon as the load is removed. If engine driven, the engine should be allowed to run idle for at least 10 minutes after the load is removed so that the parts affected by combustion may readjust their temperatures gradually.

Cylinder Oil—Cylinder and piston rod lubrication is usually no problem if the gas is dry and pressures are nominal. A good 30 grade oil usually will suffice. Oil additives seem to be of no particular advantage to the compressor cylinder or packer. Wet gases or high pressures demand different treatment. In some cases the use of oils of around 60 grade will be all that is necessary to take care of this situation. Steam cylinder oils, compounded with tallow, make an excellent lubricant for such purposes, but their liabilities usually result in ultimately removing them from service. Any slight failure of the double acting wipers permits the compounded oil to be carried into the crankcase, causing the viscosity of the crankcase oil to skyrocket. Further, such compounded oils produce an excessive carbon residue, which is highly undesirable on the discharge valves.

When compressing plant vapors, it is frequently of material advantage to have the condensate uncontaminated with anything which will throw it off color, so that it may be pumped to a white line without having to be rerun. The use of the white viscous oils will permit this to occur with good lubrication, and with considerable saving in steam. The quantity of oil required for cylinder lubrication is surprisingly low. After the rings have seated, cylinders handling dry gases at nominal pressures can usually be cut to around 5 million square feet per gallon feed. We indicate this and subsequent oil figures with great reluctance, for some will find they do well with half this amount, while others could not get along without doubling it. Such figures are only to suggest an order of magnitude. Wet gases and high pressures can demand double this oil rate.

Too much oil will often result in excessive carbon deposit on the discharge valves, particularly if the ratio of compression is on the high side. The adequacy of lubrication can be checked at the outset by frequently removing an intake valve and feeling the cylinder wall for an almost imperceptible oil film. Later it is wise, after a sufficient time has elapsed to make it significant, to insert a micrometer through the valve opening and measure the wear rate of the liner as a check on the lubrication. The new style lubricator tops which are equipped with glycerin or similar visible liquid, through which the lubricant may be pumped under pressure, make the measurement of feed rather difficult. With this type of equipment, the total number of drops per minute for all feeds within one compartment must be counted, and the total oil per day fed from that compartment can be divided in the proportion as the number of drops for any feed bears to the total drops.

Packer lubrication is usually the same as that for the cylinder in quality, though in certain cases, where the oil used in the one location is not the best for the other, we have found it advisable to use different oils for the two, from two different lubri-

cator compartments. This is the unusual case. We have described the "grease gun" fittings on the inboard oil feed previously, and the use of these to lubricate the packer, far in excess of the capacity of the lubricator, will be found highly useful during the break-in period. After break-in, on gases at nominal pressures, lubrication may often be cut as low as 5 million lineal feet per gallon.

Valves—Valves constitute perhaps the major feature of the compressor. The design of the valve must be such that the pressure drop through it will be very small, so called "valve velocities" will be low which means that a sufficient number of valves and the lift area of each must be great enough to keep the velocity of the gas through the valve down within acceptable limits. In reviewing compressor offerings, this is an item which must not be overlooked, and further, it must not be assumed that all manufacturers calculate the valve velocity the same way. This may seem like a surprising statement, but if the reader will divide the cylinder displacement in cubic feet per minute (of both ends of the cylinder) by the lift area of all the suction valves in square feet, he can work out his own valve velocity in lineal feet per minute which good practice likes to limit to 7500.

In order to keep valve velocities (and the resulting losses) down, large cylinders, and many of the pipe line cylinders which compress through low ratios are frequently made with double deck valves. This permits doubling the valve area within the same physical limitations of available cylinder wall area.

Manufacturers normally supply their valves with steel discs, hardened and lapped to a fine finish, with springs to match the lift of the disc and its mass. Independent suppliers pressure the customer to replace the steel discs with those of one of the various varieties of phenolic resin, claiming longer life and lower cost. Sometimes this claim can be met, but all too often the user finds himself installing discs which are materially thicker than those which were originally supplied, resulting in a greatly decreased lift of the valve, and consequent raising of the valve velocity, and a general increase in losses. If thicker discs are used, the valve body must be machined a corresponding amount so that the design lift will be preserved.

In an earlier section we have warned about checking the proper installation of the valves. Earlier compressor valves were made reversible, so that a suction could be made into a discharge readily. This possibility is seldom found in currently made compressors, for the reason that in one of the positions, the center bolt which held the assembly together would fall into the cylinder if it became loose. This disconcerting phenomenon became the source of too many complaints, and designers set to work developing valves on which the center bolts backed away from the cylinder barrel instead of into it, should they come loose. In most cases this was done at the sacrifice of valve interchangeability, which was a doubtful asset in the first place. However, even with this change, it is usally possible to install valves backwards in the cylinder if the mechanic's mind wanders during the operation.

Gaskets—Solid copper gaskets work well on low-pressure cylinders. Where these will not stand the seating pressure, soft steel gaskets seem to be preferred. A few prefer the aluminum gaskets, and these seat well, but have no hoop strength, hence it is necessary to have them made very accurately so that their outside diameters will be as big as the recesses into which they fit, so that the recesses will back them up and make it unnecessary for the gaskets to withstand any pressure in bursting. Gasketing is usually a real problem on high-pressure cylinders, and there are some who are still optimistic enough to believe they can lap the valve into the recess with lapping compound and operate without any gaskets whatever. Slight gasket leaks in high pressure cylinders can quickly slot the recess, causing an appreciable amount of tedious hand work in the repair process, hence it behooves the operators to watch the discharge gas thermometers and feel the valve covers frequently.

Rings—High discharge temperatures can also be caused by rings which are not seating, or which are badly worn. When such trouble is indicated, the valves should be checked first, then, if the trouble is not corrected, the rings should be examined to insure that they are seating, or do not have excessive wear or end gap, or that the grooves are not "veed" in the piston, and that the liner is not scored or out-of-round. At any sign of cylinder trouble it is always wise to make a capacity check of the calculated throughput against the metered throughput. If no external trouble is noticed it is still the wise thing to do to make routine capacity checks at least semi-annually. A "payout" can normally be obtained through proper maintenance if the cylinder is found to deviate from its calculated capacity by more than 10 percent.

High ratios of compression will produce high discharge gas temperatures, such temperatures being readily calculated, or read from charts prepared for this purpose and found in various handbooks. If high ratios of compression are contemplated, the volumetric efficiency of the cylinder should be calculated to insure that the cylinder will not be shut off, that is, that the efficiency will be well above zero. High clearance in cylinders produces a low volumetric efficiency. In every case, the "rod loading" produced by the differential pressure across the piston should be calculated and checked against the maximum allowable loading from the manufacturer's design calculations. Gas discharge temperatures above 300 F. are to be frowned upon, as they accelerate the carbon deposit on the discharge valves, and often build up deposits of carbon in the discharge fittings which eventually results in excessive pressure drop, causing higher horsepower loads and reduced cylinder capacity. Hot cylinder jackets should be regarded with suspicion, as frequently this is an indication of air or gas in the jacket water which is interrupting the water circulation.

Safety Valves—The safety shut-

downs should be tested at least monthly to insure that they are always in operable condition. It will be safer to actually make them function as they are supposed to than to develop a synthetic test which leaves any part of their function to conjecture. The safety valves around the cylinder should also be tested at similar intervals. It will be found most convenient to post a schedule for such testing of each item which can be filled out and signed by the responsible party. This will then become a matter of record, which may prove invaluable in the event of accident.

MAINTENANCE

Maintenance on the compressor consists of principally valves, rings and packers. It is wise to know when to anticipate trouble, so that it can be corrected at the operator's convenience, rather than make its own demands upon the operator's inconvenience. It will take some time, keen observation, and good record keeping to work out a maintenance schedule which will permit the maximum safe run on any of the equipment. Compressor operation on dry gases at normal pressures can usually be estimated at a one year run, and may possibly be extended as long as two. High pressure cylinders must usually be checked over in approximately six months. These times are merely to suggest an order of magnitude. Each operator should work out the optimum inspection times for himself for each class of service.

Valve Maintenance—When they need it, valve seats may be ground. If the discs show slight wear, they can in some cases be turned over. Occasionally it may pay to reface valve discs on a magnetic chuck, using a grinder. If this is done, a maximum of around .005-inch is all that should be removed from the disc. Check the valve springs, and replace whenever necessary. Check the completed job with distillate after assembly. Keep a stern watch on the discharge valves for carbon accumulations. This may prove to be the bottleneck which requires first attention.

Ring Maintenance—Check the piston rings for radial wear, which will usually show up by excessive end gap. Three piece segment rings with an internal expander are the type most universally used today. Various mixtures of bronze rings seem to be preferred for quick seating and freedom from scuffing. They may wear more rapidly than iron rings in some instances, but their ease of seating and freedom from scuffing will usually be considered to more than make up for any shorter life experienced. Occasionally phenolic resin rings will work out wonderfully well under difficult circumstances, and at a reduced cost. We have known of such instances. We have also known of instances where, after months of seemingly no wear, they suddenly wore out over night, and the expanders then proceeded to ruin the liners. They are a great help where sour gases are encountered.

The sides of the ring grooves should always be checked carefully for being true, particularly in high-pressure pistons, as this is probably the first point of ring trouble. Grooves have a tendency to "vee" causing blowby and rapid ring wear. Experience has shown it wise to anticipate this trouble and lay in rings which are .025-inch over width. Grooves can be trued up to this oversize, and later on can be turned again in still more increments of .025-inch each. Side clearance in the ring grooves in high pressure cylinders should not exceed .002-inch when a new fit is being made.

Cylinder Liner Maintenance—Cylinder liners should be reconditioned when they are scuffed, out of round, or are worn excessively. If the barrels would wear true, it might be another story, but they invariably wear more at certain points than at others, hence it is wise to recondition when wear reaches the order of around .002-inch per inch of cylinder diameter. After using the practice for many years of reboring to standards of oversize, we have found it better in the overall picture to replace the liner, or spray it back to standard size wherever possible. This permits further use of the piston and does away with the necessity of carrying so many oversizes of piston rings on the shelves. Pistons normally wear much more slowly than liners, and this fortunate circumstance can be made use of. Unfortunately, not all cylinders are lined, and most of them which are not will not stand sufficient cut to install a liner of standard diameter without jeopardizing the maximum working pressure. Many operators are using the metal spray process to good advantage for this work. Pistons may be built up this way, too, although it is not good practice to run a sprayed piston against a sprayed liner. Good success has resulted with spray up to 1000-pound operating pressure, though the higher the pressure the greater the risk. Metal spray work is only as good as the technician who does the work. Our experience has indicated good spray men to be few and far between. If the reader has had sour experiences with spray work, let him regard his workman with a certain amount of skepticism. It is not meant to infer that all spray jobs come out perfect, but in the hands of a good man, better than 90 percent should work out well if the application is a proper one and is well done.

Piston Rod Maintenance—Allowable piston rod wear is an inverse function of pressure, rods at normal pressures seeming to stand a wear of .004 to .006-inch per inch of diameter with good packer operation. Rods hardened to a Rockwell C of around 50 usually show such a low wear rate that the extra cost of the hardening appears well worthwhile. Successful operation of sprayed rods has resulted at pressures up to 1000 pounds. This is found to be a very useful method of reconditioning rods, as it does not call for the rod to be removed from the piston. The removal of the rod is quite a chore in some machines, involving considerable labor, and occasionally resulting in a broken piston, where the interference fit was rather heavy.

The porous nature of the sprayed surface is particularly conducive to good lubrication. Rods can be chromed and ground, but this is a rather expensive procedure. It does produce a good durable surface. When replacing the rod, make sure that the crosshead adjustment is such that the rod runs level through the packing. Make sure, also, that the piston is tight on the rod.

Packer Ring Maintenance—The majority of rings sold for packers are of bronze. Like the piston rings, they

seat readily and go to work easily. Various types of phenolic resin rings have been found successful in certain applications, and are quite valuable with sour gases. The manufacturer will specify the packer to be used for the various pressures, the variation occurring in the number of sealing pairs. Most pairs of such rings consist of one radial cut 3-piece ring towards the pressure, and one sealing ring away from the pressure, in the same cage. These sealing rings are usually made either with tangent cuts, in 3 pieces, or they consist of three radial cut rings with 3 small pieces or bridges to seal the cuts, which are usually referred to as "6-piece bridge" rings. From observations of wear characteristics we have a personal preference for the bridge ring, though we appreciate that the trend is the other way. The tangential ring is much easier for the manufacturer to make. Manufacturers differ in the number of breaker rings used, but there should never be less than two in any packer. The garter springs used around the rings are normally made of a stainless material.

The packing should be serviced before the ends of the sealing pairs butt and generous end clearances given. At this time check the wear on the sealing faces of the cages with a straight edge, and grind true if any wear is visible. Replace the sealing pairs of rings when they become thin radially. One side of each ring will be stencilled for mating. Make sure that this stencilled side is not against the seal face of the cage. If packers seal well, their running period may be six months in high pressure service, to perhaps as long as two years in low pressure units. The theory of the breaker rings is quite different from that of the sealing pairs. They are normally made in three radial cut segments, of single thickness sufficient to occupy the whole cage. The designer will provide only enough end clearance so that when the surface against the rod is worn in, the segments will butt. These rings tend to reduce the pressure and duty on the sealing rings, but what is more important, if they are operating properly, they reduce or slow down the back flow of the high pressure gas, trapped in the sealing cages during the discharge stroke, while the suction stroke on the frame end of the cylinder is taking place. When the breaker rings are not functioning properly, the high pressure gas trapped in the sealing cages, in its rush to get back into the cylinder whose pressure has been so suddenly reduced, blow the sealing rings apart momentarily, resulting in rather rapid spring breakage. When packers are found with springs around the sealing rings broken, the packer rings should be checked for adjustment.

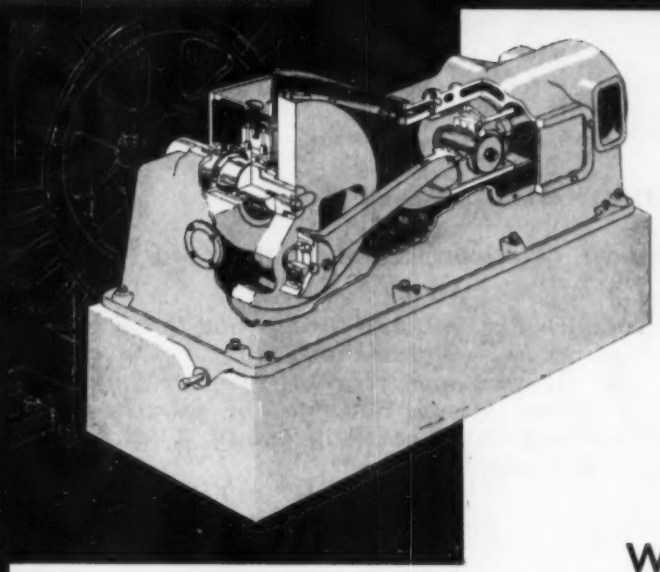
Crank Bearing Maintenance—Crank bearings should be checked often enough to insure that the clearance does not become excessive. Even with gas engine pistons working on the same shaft, the much higher loading of the compressor rods will normally make these cranks the most rapidly wearing of all bearings in the machine. In the general case, inspections at six-months intervals is usually worth while. The manufacturers recommendations should be followed in the adjustment of these and the other bearings on the machine. Earlier it was noted that the rod loading limitations should not be exceeded. Many manufacturers will still further curtail the loading when the cylinder is operating single acting, for the sake of the crank bearing which gets no reversal with such operation, and therefore may not be so well lubricated. Single acting limitations should be noted before such operation is contemplated.

Check Cylinder Clearance—When discrepancies between calculated and metered capacities are not corrected by working over compressor valves and rings, it may be found advisable to check the actual cylinder clearance. The manufacturer usually calculates this value, and occasionally he is wrong. Such a measurement is somewhat of a chore, though it can be done with water by sealing all the valves but one intake, and blocking around the piston with grease. The trouble may also lie in the lack of a suction or discharge surge chamber, or the use of one too small. Pulsations can readily cause such discrepancies, and to determine whether or not such effects are troubling the cylinder, the indicator is about the only useful trouble-shooting instrument. The principal difficulty in using the indicator will lie in obtaining an accurate indicator motion. For this it will be best to use an instrument with a reducing motion incorporated within it. Motion from the crosshead should be carried to the indicator with a steel tape, using a sufficiently heavy spring against the tape to insure that there is not the slightest amount of whip in the tape. If necessary, watch the tape with a stroboscope to insure against whip or lost motion. Try to avoid the use of wheels for the same reason. See that the indicator string does not pull at an angle to the tape, and that the tape runs in line with the crosshead. Indicator cards accurately taken will reveal all the pressure disturbances to the cylinder, as well as showing the performance of the rings and valves. In most instances the difficulty in obtaining indicator cards has been amply paid for in accurately locating trouble.

Experience is the priceless ingredient in good compressor operation. It is hoped that the reader may pick up a few points in the foregoing from the experience of others which may prove profitable. ##

Meet the Author

ROBERT S. RIDGWAY has been chiefly concerned with internal combustion and engineering since he graduated from California Institute of Technology in 1924. Since joining Standard Oil Company of California in 1925, he has worked with the Natural Gasoline department, and has held the position of mechanical engineer since 1928. As Standard of California has expanded its natural gas and gasoline activities, Ridgway has been concerned with problems arising in both gas engine and compressor operation, maintenance, installation, and design. Several other articles by Ridgway have been previously published in PETROLEUM REFINER.



RECIPROCATING COMPRESSOR
SPECIAL REPORT . . .

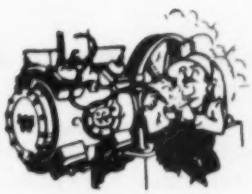
5. Compressor Trouble-Shooting

If you run into trouble—here's what to look for . . .

Water Cooled Compressors

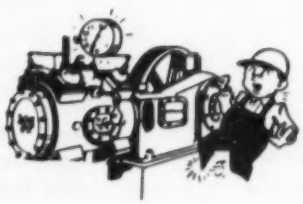
Failure to deliver required capacity may be caused by . . .

- Excessive leakage in pipe lines and fittings and through valves
- Discharge pressure higher than rating
- Speed incorrect
- Filter clogged • Worn piston and rings
- Faulty Valves • Packing leaking • Suction valve unloaders holding strips partially open



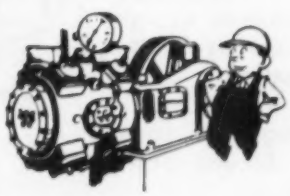
Compressor fails to deliver required pressure—look for . . .

- Demand greater than rated capacity of unit
- Speed incorrect
- Worn rings
- Packing leaking
- Excessive leakage in system and internally



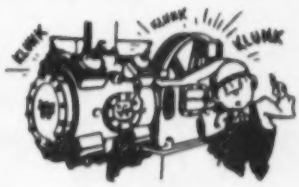
Failure to deliver air may be due to . . .

- Suction line blocked — dirty filter
- Valves improperly installed
- Suction valve unloaders stuck in unloaded position • Strips missing from valves



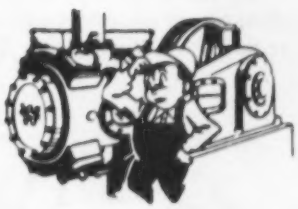
Compressor knocks can caused by . . .

- Loose flywheel or pulley
- Excessive wrist pin and bushing clearance
- Excessive crank pin bearing clearance
- Excessive crosshead clearance
- Main bearings need adjusting
- Loose valve in cylinder • Loose piston nut



Compressor overloads motor—check to see if . . .

- Electrical characteristics of power lines incorrect
- Multi-V-drive belts pulled excessively tight
- Discharge pressure higher than rated • Speed greater than rated
- Discharge line restricted



Compressor overheats—could be . . .

- Broken valve strips
- Cooling water inadequate
- Filter clogged
- Discharge pressure higher than rated
- Internal leakage

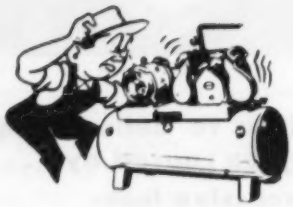
Air Cooled Compressors

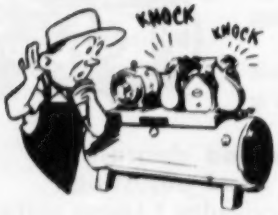
Failure to deliver required capacity may be caused by . . .

• Excessive leakage in pipe lines and fittings and through valves • Discharge pressure higher than rating • Speed incorrect • Filter clogged • Worn piston and rings • Faulty valves • Blown cylinder head gasket • Suction valve unloaders holding strips partially open • Intercooler leaking • Belt slipping

Failure to deliver air may be due to . . .

• Suction line blocked—dirty filter • Valves improperly installed • Suction valve unloaders stuck in unloaded position • Strips missing from valves





Compressor knocks can be caused by . . .

• Loose flywheel or pulley • Excessive wrist pin and bushing clearance • Excessive crank pin bearing clearance • Main bearings need adjusting • Loose valve in cylinder • Loose unloader • Excessive end play in motor rotor • Motor shunting back and forth due to belt misalignment or unlevel mounting

Compressor overloads motor—check to see if . . .

• Electrical characteristics of power lines incorrect • Multi-V-drive belts pulled excessively tight. • Discharge pressure higher than rated • Speed greater than rated • Discharge line restricted • Low voltage

Compressor overheats—could be . . .

• Broken valve strips • Wrong direction of rotation • Filter clogged • Discharge pressure higher than rated • Internal leakage • Insufficient lubricating oil

When intercooler valve blows—look for . . .

WHILE RUNNING UNLOADED • Broken or leaking high pressure discharge valve strip • High pressure unloader leaking air • Defective or stuck low pressure unloader • Blown high pressure head gasket

WHILE RUNNING LOADED • Broken or leaking high pressure suction or discharge valve strip • High pressure unloader stuck in unloaded position • Blown high pressure head gasket

These pictures were taken from a Worthington Corporation Bulletin No. P C-509P. A copy may be obtained by writing to Advertising & Sales Promotion Department, Worthington, Corporation, Harrison, New York.

Is Your Distillation Column in Balance?

The operation of a distillation column is more costly if it is not in balance. Here is a non-mathematical discussion of column balance and how to achieve it.

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IN A PREVIOUS paper[1] the writer introduced the concept of the "balance" of a distillation column. For a given feed composition there is a single division of the feed between overhead and bottoms, a single "balanced" operation, that gives maximum purities for both product streams. For any other division of the feed of necessity either heavy material must be forced into the overhead or light material must be forced into the bottoms. From the analogy with a knife-edge weighing scale and its ability to "tilt" in either direction, this property of a distillation column of producing either too much overhead or too much bottoms is termed the column "balance."

Let us consider how this term is used. For a particular distillation column the purest products are obtained with an exact 50-50 split between the overhead and bottoms. But in operating this column it is more important that the bottoms product be pure than the overhead, so the column is set to give 51 percent overhead—49 percent bottoms. This causes a high purity for the bottoms but, of course, 1 percent of heavy material is forced into the overhead. The column is "out of balance" towards the overhead by 1 percent.

Now a cold rain strikes this column and the control system reacts to increase the bottoms and give a 50-50 split, so that momentarily both products have a high purity, the column is balanced. But after the rain the sun comes out and the warmer water from the cooling tower causes the column to shift to 52 percent overhead—48 percent bottoms. The bottom product remains pure but 2 percent of heavy product is now forced into the overhead, the column is out of balance towards the overhead by 2 percent. Later the percentage of heavy material in the feed drops 2 percent from 50 percent to 48 percent. Then for 52 percent overhead—48 percent bottoms the column is again in balance and good purities are obtained for both product streams. But when the heat duties return the tower to 51 percent overhead—49 percent bottoms, the tower goes out of balance towards the bottoms and 1 percent of additional light material shows up in the bottoms. The tower then must be adjusted so that the division is 53 percent overhead—47 percent bottoms. This returns the tower to being 1 percent out of balance towards the overhead, the bottoms is again pure and 1 percent of heavy material is forced into the overhead.

"For a given feed composition there is a single division of the feed between overhead and bottoms, a single "balanced" operation, which gives maximum purities for both product streams."

This constant shifting, this "balance swing," continues indefinitely. The balance depends on so many variables that its value at any one moment becomes a matter of chance. It is to be emphasized how sensitive the product purities must be to the balance. Thus in the column of the example, consider that the feed is 100 parts and that the reboiler vapor is 200 parts or twice the feed. But an increase in the reboiler vapor of 1 part (0.5 percent of the reboiler vapor) puts 1 part of additional heavy material into the 50 parts of overhead, or 2 percent based on the overhead. To summarize, a shift of 0.5

percent of the reboiler vapor load has added 2 percent of heavy impurity to the overhead composition. This multiplying effect of small percentage changes in the heat duties giving large changes in the product purities can be caused equally by any other of the tower variables, the condenser temperature, feed rate, tower pressure, etc.

It is to be noted that the balance swing is not a direct and logical function of the external conditions, rather it is changed in amount and can even be reversed in direction by the reactions of the tower controls. But it is to be emphasized, the shifting of the column balance is not stopped by the control system but only modified, it is as likely to be increased in amount as lessened. Indeed, the tower controls are a major source of the variations in the balance. In the example just given, the increase of 0.5 percent in the reboiler vapors is well within the normal variations of the instrument controlling the reboiler heat. And variations produced by any one of the other major column controls can have an equivalent effect.

This would seem to be an easy and obvious subject, familiar to all and worth only a few pages of small talk. But it is not. The reception given this concept of the column balance in the previous paper was not kind. One critic regretted an "attack" on the work being done on plate efficiencies, and a second was sorry to see such confusion introduced into a difficult subject. A third pointed out that our body of distillation theory was quite complete and interconsistent, and that there was no possibility of errors of the type "imagined." The writer was termed "argumentative" for rejecting this judgment. A common form of criticism was to discuss how a distillation column "really" behaves, "This increases the reflux which, etc., etc." Evidently what is required on this subject is not a mild academic discussion with mathematical background as in the previous paper, but rather a little gentle head-bumping of the facts-is-facts type. The actual astonishing situation needs to be described carefully and with sufficient cut to make an impression on some very well entrenched ideas. There needs to be caused a sharp break in our pious certainty that we must be managing the columns exactly right because there are so many of them. The tone of this writing was deliberately selected as necessary to the subject.

First we need to select a measure for our subject, something at which we can point our finger. For this we can use a particular ratio and its numerical value. It is believed that with our usual design conditions most columns intended for sharp separations in the petroleum and petrochemical fields are capable of purities of the order of 99 percent or better for both product streams. But for the actual operating towers, and because of the lack of balance, it is believed that the average is to find one stream with a purity in the range of 93-97 percent. And purities of 90 percent and below are believed to be more common than those above 97 percent. Then if these values are considered reasonable, we can say for our ratio that the average measured impurities in one product stream divided by the minimum impurities obtained with the ideal balanced operation has a numerical value in the range of 5 to 10. These figures are of necessity very rough averages quickly arrived at, and are based on one man's irregular observations over a length of time and for columns with a wide variety of uses. Nevertheless this value of between 5 and 10 is believed to be conservative, the 10 is more likely to be right than the 5.

Any objections to the importance given here to the column balance can be countered by this value of this ratio, there averages 5 to 10 times as much impurity in one product stream as there would be if we could balance the columns. Any arguments as to what we should do or might do can be answered by the fact that we do not. The measure of our subject is our present failure to control the columns. If the value of this ratio of actual to ideal impurities were 1.01 to 1.0 the balance should be of theoretical interest and worth discussing. If it were 1.1 to 1.0 it would be worth deliberately including and correcting for in the design procedure. If it were 2.0 to 1.0 it should take a full half of our consideration and care. In contrast to this we have the astonishing situation that our ratio is of the order of 5 or 10 to 1, and the column balance is largely ignored! Indeed, it is even doubted that the balance problem "exists"!

Economic Losses—This problem of giving the subject of the column balance its true weight, of making it seem as important as it is, is a difficult one. One reason for this is that we lack the comparison of the balanced operation. A means of obtaining this comparison for a particular column is as follows: First, determine the product compositions for the normal operation with one product pure and the other taking the balance swing (containing varying amounts of impurities); then adjust the control temperatures so that these are reversed, the first product takes the balance swing and the second is pure, and again determine the compositions. The balanced operation would be represented by the two sharp separations, the high purities for each product. The economic loss that must result from our not being able to maintain both high purities simultaneously will be immediately obvious.

We can use this quickness with which we understand money to give a more general measure of the importance of our subject. Economic losses which result from our inability to balance the column can be listed under three types as follows:

The first and most obvious of these is the direct and continual loss of product dollar value resulting both from lower product recoveries and from higher percentages of impurities. We are discussing, of course, only towers intended for sharp separation of components. We have already said that on the average and because of the balance, half of the product streams will have a 93-97 percent purity, and that a 99+ percent purity is available from the heat duties and numbers of plates used. Then 3 percent to 6 percent of additional impurity is in one product stream because the columns are not held in balance. The cold cash dollar values represented by these simple figures remain unbelievable with the most conservative of estimates. For many, many towers this loss exceeds the entire cost of the operation itself. And extended to

the national average, these losses probably very nearly equal the total costs of the distillation operations. Certainly they are of the same order of magnitude.

The second type of economic loss because we do not balance the columns is excessive operating costs. First of these costs is in the care and equipment that goes into maintaining "constant conditions" on the columns, feed surge drums, regulators, etc. A second cost is that of the continuous and rapid testing required in attempting to hold the columns in balance. But these are probably small compared to the costs of the excessive heat inputs. The heat use is a major cost of a distillation operation and, because of uncertainties about the balance, a common ratio for both design and operation is that the heat input should be 150-200 percent of the theoretical minimum for the separation. But it can be shown by economic analysis[2] that no heat use of more than 120 percent of the theoretical can be justified for any except extreme cases. This extra heat input represents a sort of margin of safety, and the total heat use could be reduced by roughly one-third if we could actually control the columns. It is to be noted that this overuse of heat represents a loss of capacity as well as heat cost.

A curious factor here is that excessive heat duties make the towers more difficult to balance and so can easily result in poorer rather than better separations for the one product stream. With increasing heat inputs a given control range becomes a smaller percentage of the total and so more difficult to hold. Cases in which better separations are obtained with decreasing heat inputs are not rare and can easily be misinterpreted.

The third type of economic loss is not the less real because it does not have a definite dollar measure. It results from the confusions and misdirections in our engineering thinking because we do not have a complete and inter-consistent body of theory that applies to the actual operating columns. We have not "completed the circle" in our reasoning, and the resulting rough edges extend throughout our practice of distillation.

Thus as an example, we are unable to project operating data from existing columns to the design of a new column, but must return each time to the laborious plate-to-plate. The only factors extending from one operation to the next are the rough "reflux ratios" and these are very poor measures of the actual heat degradations that take place across the columns.

This is in contrast to such fields as fluid flow, heat exchange, etc., in which massive correlations for predicting new operations have been built up from data on existing equipment. It is believed that it is this confusion resulting from the chance of the column balance which has prevented the plotting of inter-consistent separation vs. heat duty data from existing columns, and has obscured the simple entropy—separation functions that underlie the distillation phenomena.

Efforts to organize actual data from operating columns have always taken the form of elaborate determinations of plate efficiencies, and efforts to correlate these have given the familiar shotgun scatterings that indicate an uncontrolled variable. Because of the balance we are actually not able to correlate the operation of the same column in the same service from one day to the next, as witness the statement, "It is, of course, well known that the plate efficiencies vary from day to day."

Concept of Balance—If we have thus at least suggested the continuing dollar importance of our subject, let us next turn to the problem of including the balance concept in our reasoning. Many of us have a submerged feeling for the balance phenomena resulting from our familiarity with the towers. But this "feeling" is not part of our organized thinking on distillation and commonly does not reach the talking level, let alone appear in print. We simply have no words for discussing the subject. Let us consider the line of reasoning required and the difficulties encountered in extending these "feelings" on the column balance into a broad and usable concept, an organized and worded way of thinking that actually applies to the columns. Our purpose is to make it seem entirely reasonable to deliberately control the columns for the balance so that both product streams can be obtained with continuous high purities. As this differs from our conventional thinking on the subject it will need to be stated strongly.

"The property of a distillation column of producing either too much overhead or too much bottoms is termed the column 'balance'."

We can begin with what seems to be the single most difficult part of this subject. No one can doubt that a column which should by feed composition give a 50-50 split can be forced to give 75 percent overhead and 25 percent by adjusting the heat duties. But that such a column in controlled operation should be giving a 52-48 split (2 percent of heavy component forced into the overhead) because of the heat duties seems impossible to us, this in spite of the fact that we are continually adjusting the heat inputs to hold the product compositions. The miraculous agent by which the exact 50-50 split supposedly is maintained is referred to vaguely as "the control system." We seem unable to grasp the fact that with present instrumentations a poor separation is continually being forced on one or the other of the product streams by the column heat balance, and that this separation must be independent of the number of plates that are present. The origin of our troubles here would seem to be in the plate-to-plate approach to distillation which states that for each end product composition there is a single corresponding number of plates. This method does not recognize any differences between the desired and the actual divisions of the feed between the product streams.

There is an Alice-in-Wonderland touch, a happy mislogic, in our thinking in this region that the writer has not been able to unravel. We are so certain that the product compositions are tied to the number of plates that one half expects to see the towers lengthen or shorten with successive composition reports from the laboratory. And the fact that they do not so change in no way disturbs our

faith. It is well known that our capacity for rationalizing is infinite. Nevertheless a person who watches the towers, who reads the compositions and adjusts the conditions accordingly, and who remains assured that there is a fixed relation between numbers of plates and end product compositions, such a person ought to feel some small signs of strain. But the writer has not observed so much as a twinge.

Various arguments and thought arrangements could be advanced at this point, but it is suggested that the easiest course is simply to start over at the beginning. And that beginning is the fact that the amount and composition of one end product is set by the tower heat duties, by the balance, independent of any number of plates (above a minimum) that may be present. The actual divisions of the feed between the overhead and bottoms as obtained from the towers are not the ideal ones that give the purest products. The measure of this is the actual behavior of the columns. Let the reader understand, exactly to the extent that any theory disagrees with this fact, that theory is wrong. This is the necessary beginning, the original basis, for the development of any theory that can apply to the actual operating columns. Under present control arrangements the ideal balanced operation is so momentary as to be non-existent. Until the reader breaks himself to these facts and their implications he is wasting his time on this subject.

A point to be emphasized is that there is no half way here, it either is or it isn't. This is not a case of different words for the same fundamentals. If we accept the fact of one end product composition depending on the balance, then we think differently, we act differently, and we expect different results. Specifically we think in terms of the balance and we deliberately instrument and control the column for the balance.

It is fantastic that such an elementary and seemingly unavoidable point would need to be belabored with such emphasis. But it is the writer's experience that it does. The difficulty is that if we accept the idea that one product composition is set by the heat duties and is independent of the number of plates, we are immediately outside of any body of distillation theory we now have. And here we have the crux of our subject, the fundamental difficulty. For like an overcoat on a cold day, we need our theory. A basic comfort is to consider ourselves consistent, to feel that we can proceed logically from one point to the next. But if we admit to ourselves that a single number of plates with fixed reflux conditions can give a wide variety of end product compositions we enter into an entirely new and unorganized area, and one that at first glimpse seems thoroughly confused. And so carefully and protectingly, like a clam disgorging a sharp pebble, we reject the idea.

"The subject of 'balance' is a very controversial one. Some consider it an attack on the work being done on plate efficiencies. Others feel it is just a lot of confusion introduced into a difficult subject. Still others consider the errors of this type are just imagined."

In some years of following the distillation literature the writer has never seen mention of this idea of poor separation being forced on a section of column by the heat duties, of one separation being independent of the number of plates. We simply do not have even a beginning of a body of theory that would provide an inter-consistent picture of a column operating out of balance. It needs to be realized that the heat duties and the numbers of plates used only make certain separations available and that for the ideal balanced operation alone can these separations be reached. The inter-relations of the variables for this ideal operation are a line, an envelope, a limit to be approached, enclosing the area of the actual operation of the columns. And within this area our variables wander quite freely, depending only on the chance of the balance.

Surely we have told the mountain to come to us long enough. We should at least feel a need for a body of theory that would provide a usable picture of the actual operating columns. In considering this particular development, it should be noted that the plate-to-plate approach, with its fixed end product compositions and dependent number of plates, has exactly the worst possible geometry of the variables.

One difficulty, and a very real one, in presenting this subject is that it is fully as simple and elementary as it seems. Surely the division of a single feed between two product streams is the easiest of arithmetic. The trouble comes in trying to fit this basic idea into our elaborate and frequently top-heavy body of distillation theory. The writer once explained this problem of controlling a column for balance to a group of visiting high school students—honor students it is true—with seeming complete success. It was obvious to them that if high purities were to be obtained then the proportioning of the feed between the overhead and bottoms would have to be controlled very precisely. Otherwise impurities would, of necessity, be forced into one or the other of the product streams. The same afternoon the introduction of the subject to a group of trained engineers led to a discussion of how a tower "really" behaves, "This increases the reflux which etc., etc."

Another difficulty in presenting this subject is the idea that we are already quite familiar with the balance under other words, that this is an unfortunate circumstance and we are doing all that is reasonable. Usually it is considered that great care should be taken in imposing "constant conditions" on the column. Surge volume should be provided so that the feed composition does not vary, and all flows must be carefully held constant. Temperatures of heating and cooling streams are to be watched closely.

And to compensate for heat effects that cannot be controlled, such as atmospheric temperatures, product compositions must be determined frequently and as rapidly as possible so that the necessary adjustments can be made before any great amount of impure product is obtained. Commonly those familiar with these arrangements are quite surprised at the idea of actually controlling the columns for the balance.

An easy and convenient sophism on this subject is to doubt the "existence" of the column balance. Inasmuch as it is the writer's argument also that an adequate concept of balance does not "exist," there would seem to be agreement. The writer can only suggest that a better basis for the discussion might be whether or not it would be profitable to us for a carefully constructed concept of the balance to be made to "exist."

Instrumentation for Balance—Let us now consider the actual details of controlling a column for balance. We can begin with a pertinent analogy. In firing a furnace the usual object is to hold a constant outlet temperature on the coil. This could be accomplished by very elaborately holding "constant conditions" on the coil, constant composition and flow through the coil, constant fuel feed, constant air control, etc. We could also test the temperature of the coil frequently and make the required adjustment. The coil outlet temperature would still vary with such things as atmospheric temperature, but we could say quite honestly and happily that we were doing the best we could and that these variations must be expected, that the cure would lie in still more careful "constant conditions" and in more frequent testing and adjustment. Actually, of course, we do nothing of the sort, we put a thermocouple in the outlet line and control the firing with it. And we hold the desired temperature through wide variations in fuel, feed rate, etc.

For a second example, consider the simple problem of holding a liquid level in a vessel. Such a level can be maintained by elaborate care in controlling flows to and from the vessel. And we could regularly check the level and adjust the flows accordingly. But again we do not do this, we measure the level and control one of the flows from it.

Any number of other examples of this type could be given, and these illustrate the general rule: For a correctly instrumented operation, any one required control may be omitted with the imposing of "constant conditions" on the system. Indeed, this rule in reverse provides the best definition of our concept of "constant conditions"; it is the type of operation made necessary by the leaving out of one important control. It is the thesis of this writing that the uncontrolled variable which underlies the need for "constant conditions" for our distillation operations has the form of the column balance as presented here.

The practical solution for the problem of balance, then, becomes the proper addition of one control instrument to the conventional distillation control system. As our purpose is to insure high purity for both product streams, a reasonable way of thinking about this extra instrument is that it should deliberately permit separate and independent control of the two halves of the column. This simple point is obviously rank heresy to our conventional thinking on this subject.

For this additional control there are, as for any instrument, three requirements. The first of these is that there must be a means of measuring the variable being controlled, a sensing mechanism. We must be able to measure very small amounts of impurities escaping into the product streams. A common way of doing this is to use the multiplying effect of a number of plates to provide composition changes large enough to be measured by temperature. Thus we frequently control the heat to a reboiler by a temperature point located midway between the feed and reboiler. For our sensing mechanisms, then, we shall use thermocouples located some distances from the ends of the column. Obviously any other measure of very small composition changes in the product streams which can actuate a control impulse would be equally satisfactory.

The second requirement of our control is some means of acting to hold the balance, some means of producing minute variations in the column heat input and the resulting distribution of the feed between the two product streams. Here we have the widest latitude. Thus a small stream can be bypassed around a feed preheater to give variations in the feed temperature, or a small stream of reflux can by-pass the main control valve. Pressure or liquid storage can be used to produce equivalent effects. A hundred other means of producing these variations in either flow or heat within the column will be obvious. It is to be noted that for reasons of sensitivity, the heat effects of these special control streams should be small, equivalent to possibly 20 percent of the latent heat of the feed. This, of course, for most columns represents a small fraction of the heat duties of the condenser and reboiler.

The third requirement is that there be some sort of capacity or surge, the something extra necessary to provide a control range. Because our variable is separation, this extra capacity of necessity takes the form of additional plates in the tower. There must be sufficient plates between the control points and the ends of the column so that practically pure end products can be maintained for a range of temperatures at the control point. It is noted that the greater the liquid volume held on these trays the smoother the transitions and the longer time the control instrument has in which to act. These three general instrument requirements are illustrated in the examples that follow.

Figure 1 shows a control system deliberately designed to hold a column in balance. The feed is flow controlled, and the basic column heat duty is set by the flow of the reflux. Heat to the reboiler is controlled by a temperature point in the lower half of the column. Overhead and bottom products are withdrawn by level control. Superimposed on this conventional system is the additional control shown heavy-lined. Overhead product is fed back to the middle of the column, and the flow of this stream is controlled by a temperature point in the upper half of the column.

In the operation of this system the lower temperature point would be set high so that the bottoms product would be pure. This would usually mean that the overhead product would take the balance swing and would contain varying amounts of heavy material. However with a correct setting of the upper temperature control, a stream of the overhead product would be returned to the feed point and would simply displace the

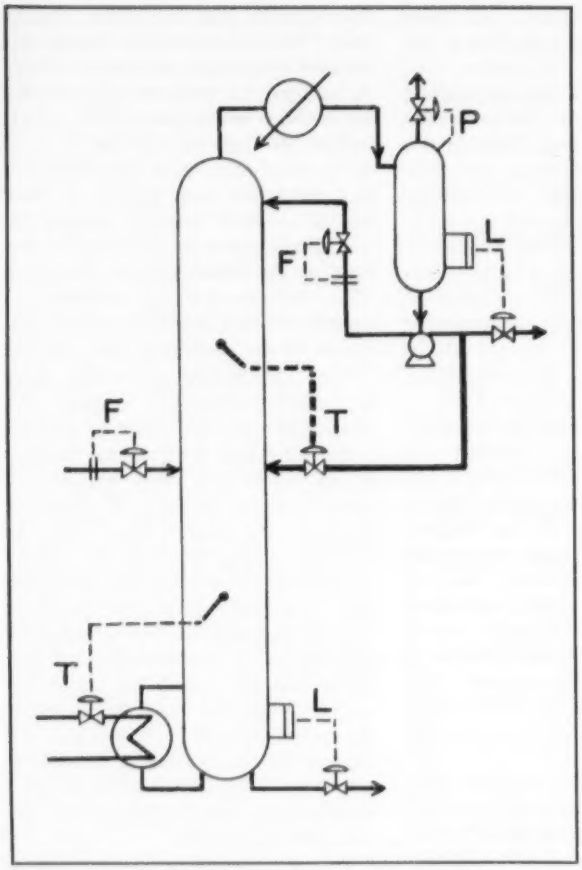

FIGURE 1—First control system for holding column in balance.

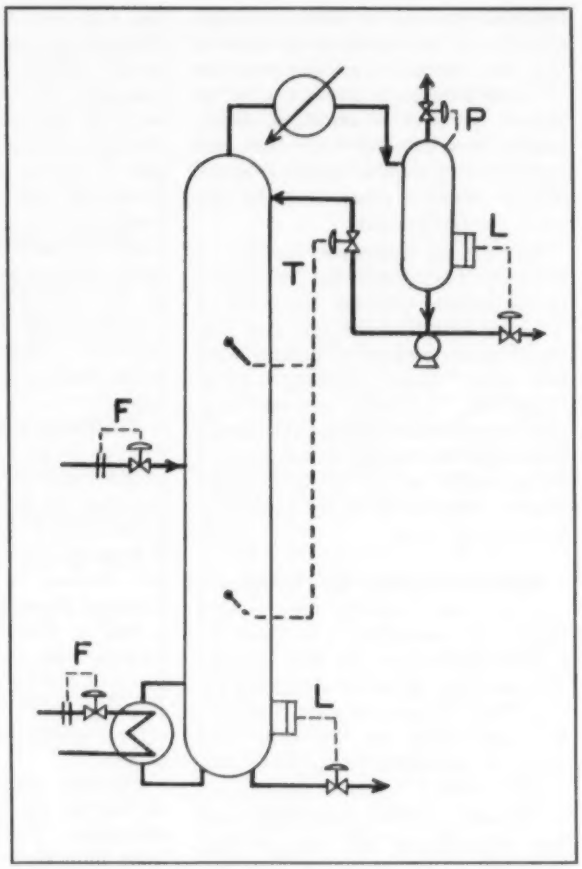

FIGURE 2—Second control system for holding column in balance.

heavy material being forced upward by the column heat balance. This would insure a pure overhead product also. This can be said another way, the varying flow back through the overhead condenser provides the fine adjustment of the column heat duties required to balance the column and give a pure overhead product.

It is suggested that for all the discussion that seems to be required, the problem of controlling a column for balance is actually this simple.

Another control arrangement that the writer believes would be satisfactory, similar to one from the previous paper, is given in Figure 2. Here the instrumentation is easier but the theory is more complex. The feed is flow controlled and the column heat balance is set by the heat flow to the reboiler. Products are withdrawn by level control. The reflux flow is controlled by the sum of the temperatures of the two control points. Without having reduced it to a completely inter-consistent system of theory, it is the writer's belief that there will be a range of a number of degrees for the sum of the two control temperatures for which the column will be in balance and both products will be pure. Provided, of course, that sufficient plates are present to give a control range. This arrangement has been included for two reasons: first, it shows the wide variety of instrumentations that are possible; and second, it illustrates the need of a usable body of theory that actually applies to the columns. What would be the behavior of a column instrumented in this manner? What are the inter-relations of the internal temperatures of a column with variations in the balance?

Numerous other control arrangements along these lines could be given, and a number of these alternates will be obvious to the reader who has grasped the purpose of the additional instrument.

At this point there is undoubtedly still with us the reader who sees no point in the instrumentations discussed above, who remains quite certain that the two temperature points cannot be controlled simultaneously and that the two temperature instruments will "fight" each other, who believes that in deliberately controlling both halves of the column we are going against fate. In Figure 3 is shown a distillation operation in which the two halves of the column are physically separated with a tank for liquid storage and a gas holder for vapor storage provided between them. The vapor feed to the upper section is held constant, and the reflux maintains a control temperature which insures a pure overhead product. Similarly the liquid feed to the bottom section is held constant, and the heat to the reboiler maintains a control temperature which insures a

pure bottoms product. It should be obvious that there is no control problem here, that both control temperatures can be maintained and that both products will be pure—within the limits of the amount of storage, of course. The specific point of this is that the reasonings which lead to the conclusion that such deliberate control of each half of the column is impossible are of the type that simply disappear with the actual doing of it. This imagined difficulty is like the mythical monster that, huge in the distance, grew smaller the more closely it was approached until finally, at hand, it was mouse sized. What the elaborate systems of counting variables applied to this problem actually show, of course, is not that the simultaneous control of both halves of a column is impossible, but rather that it requires an additional degree of freedom. This degree of freedom is provided by the flow of the recycle stream in Figure 1 and by the change in the storage level in Figure 3.

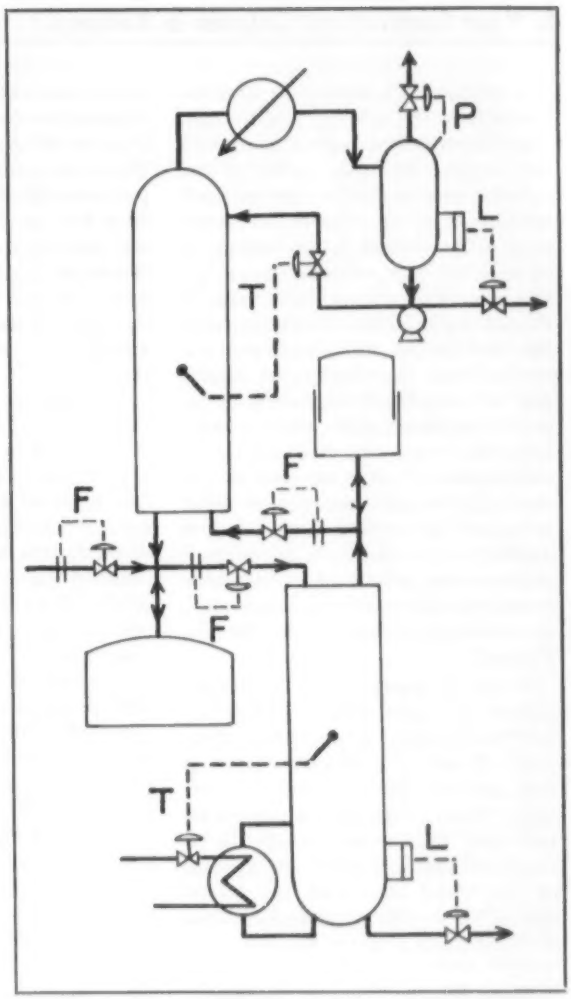

FIGURE 3—Elaborate control system for holding column in balance.

The arrangement of Figure 3 is, of course, over-elaborate. An obvious first-step in simplifying it would be to eliminate the vapor storage. The rise and fall of the liquid storage would then provide a measure of the amount the column was out of balance. But the equivalent of this rise and fall could be produced by varying the feed to the column. Or if this were not convenient we could provide the same effect in reverse, by varying the column heat balance for a constant feed. We are thus back to the arrangements of Figures 1 and 2, to the proposition of providing minute changes in the tower heat inputs to control the distribution of the feed between the overhead and bottoms streams. This transition from Figure 3 to Figure 1 should be worked out in detail by the reader to whom Figure 3 is obvious and Figure 1 is not.

But if all this seems like unnecessary complications for uncertain results let us consider the rewards of deliberately controlling a column for balance. To repeat, the advantage to be gained is that, within the control range provided, the column would continue to give high purities in both product streams for sizable variations in the column heat and weight balance. As an example for a hypothetical column, the percentage of a given component in the feed could increase from 30 percent to 40 percent, the feed rate could change from 100 to 110, the feed temperature could drop from 120 to 90 degrees. And both product purities would continue to be 99+ percent. With such a control arrangement the practice of maintaining elaborate "constant conditions" would no longer be necessary, the need for the continual quick testing of the product streams would disappear. Let us stop here and consider for a moment, these are not minor details.

A number of objections have been given to the instrumentation shown in Figure 1. A first is that it is more complicated than necessary, "The simplest instrumentation is always the best." But the simplest instrumentation is a complete manual control with no instruments at all. It is suggested that the instrument added serves a useful purpose, and that the operation itself, the care and testing required, has been greatly "simplified" in the full meaning of the word. A haphazard and slow manual operation, the control of the balance, has been made, we hope, automatic and precise. A second objection is that it is theoretically unsound to use energy to separate out a pure product and then to remix it with the feed as shown in Figure 1. Presumably it would be better to be "theoretically sound" and have the heavy impurity in the overhead than to displace it with light material, have a pure overhead, and be "theoretically unsound."

A third objection, a form of the argument for "constant conditions," is the "water level analogy." It is stated that we cannot control the flow of water to a vessel, the flow from the vessel, and the level itself, all simultaneously. Two can be controlled but the third must remain free. And by analogy, neither can we control the

heat input to a column, the heat removal from the column, and the column balance. One must remain free. But suppose we were to forget our little discussion for a moment and actually want to control all three, suppose it becomes worth money to us to do so. The answer is immediate and easy. The obvious requirement is a small third stream, a by-pass around the feed control valve perhaps, or a return from the discharged water. And we control the water feed to the vessel (the heat input), the discharge from the vessel (the heat removal), and the water level (the column balance), all simultaneously with small variations in the third stream. In the distillation systems, this "third stream" becomes the balancing stream controlled by the additional instrument, the overhead return to the feed in Figure 1.

It can be argued that this solution violates the spirit of the analogy, that no "third stream" is permitted by the rules of our little contest. And it is just such careful rules that do not apply that has caused our difficulties with the distillation systems. It is suggested that the deliberate holding of the water level with the "third stream" is an exact analogy of what we need to do with the towers.

Plate Efficiencies and Balance—Nowhere is there a sharper focus on our failure to comprehend the column balance phenomena than in the elaborate and conscientious determination of plate efficiencies for commercial columns that are reported in the literature. In the towers described in the general form of these reports, the plates on one side of the feed inlet show a continual gradient of temperature and composition and give a sharp separation for the product. The bulk of the plates on the other side of the feed inlet, however, show a constant zone with composition changes taking place only at the ends of the section, a long-centered S-type curve, and the end product purity is poor. It is always quite obvious which end product is taking the balance swing. Commonly the numbers of theoretical plates required are carefully calculated for the two halves of the column, and the ratios of theoretical over actual are listed as the plate efficiencies. Invariably high efficiencies are obtained for the one half, and low and irregular efficiencies for the other half. There are a number of mathematical paths possible by which poor separations because of balance can become low calculated plate efficiencies. The details of the use of the tower data vary from one paper to the next, but the shape of the internal conditions of a column out of balance is always the same.

Nowhere in any of these reports is there the idea that one product composition is of necessity set by the tower heat balance, that a portion of the feed is forced in to the wrong product stream independent of the number of plates that may be present, that a hundred plates of 100 percent efficiency could give exactly the same end product with only a longer constant zone.

Incidentally the careful and complete descriptions in these studies provide a beautiful picture of the operating columns and are a good beginning point for anyone interested in working on the theory of the behavior of an out of balance tower. The first step would seem to be the development of the characteristics of the central constant zone as a function of the forced end product composition.

Meet the Author

WILLIAM D. HARBERT, who is chief engineer for United Refining Company, has charge of general process and design for new construction. Before joining the Warren, Pa., concern, he was with Arthur G. McKee Company as a process engineer. He is a graduate of the University of Oklahoma, with both B.S. and M.S. degrees.

Feed Plate Location—The problem of the feed plate location is another subject that has become confused by our failure to include the balance phenomena in our theory. Consider a column giving a poor top separation because of too much overhead, that is, out of balance towards the overhead. Two views are encountered as to what should be done with the location of the feed.

- *The feed inlet should be lowered so as to provide more trays for the "difficult" overhead separation.*
- *The feed inlet should be raised so as to have more trays below the feed where they are doing some good rather than above the feed where they are doing no good.*

Neither of these, of course, touches the actual difficulty of the column balance. One form of the second argument is that the trays below the feed are efficient and those above are obviously inefficient so that by lowering the feed we are, in effect, replacing inefficient trays with efficient ones.

Considerable has been written concerning the feed plate location, and a number of more or less complex rules based on compoistion have been given for selecting the optimum. Unfortunately with our present control systems these rules have no meaning as they require the ideal balanced operation which does not exist. The general theory for the optimum feed plate location is not difficult. The requirement is that there should be minimum entropy of mixing between the feed stream and the internal streams of the column with which it merges. For partially vaporized feeds for regular systems this reduces to the rule that the flashed feed should go to the plate of the same temperature. Any temperature difference between the flashed feed equilibrium and the feed plate equilibrium represents lost separation potential. This provides a means of direct measurement as a check on the feed plate location. It may be desirable, of course, to favor one separation over the other by moving the feed inlet from the optimum, but the loss for one product stream must more than offset the gain in the other stream as measured by the ratios of the cut components. Again, how-

ever, this discussion has no meaning for a column operating out of balance.

Design Procedure—We can consider quickly the effects of including the column balance in the original design of a distillation operation. The first effect is that with the ability to actually control the columns, we can reduce the quantities of heat used for a given separation by very substantial fractions. It can be shown by economic study[2] that only in extreme cases can any heat duty of more than 120 percent of the theoretical minimum be justified, this in comparison with such outlandish values at 200 percent of the minimum which are common practice both in the design and in the operation of the columns. We would no longer need the margin of safety provided by excessive heat duties. As background here it should be noted that over the life of a column the cost of the plates and the column itself is a very small fraction of a very small fraction of the cost of the heat transferred across the column. Then any actual economic design,—as contrasted with our standard practices—favors a minimum heat duty, only a few percent above the theoretical, and large numbers of plates.

The second effect of designing for balance is that the numbers of plates in the column must be increased substantially, both to compensate for the lower heat duties and to provide the required control range for the instruments. One procedure that might be used to reach a reasonable number of plates is as follows:

Step 1. By conventional methods obtain an inter-consistent design of product purities, heat duties and numbers of plates for the idea balanced operation.

Step 2. Select the control point plates above and below the feed and estimate a range of compositions that might be encountered here both because of possible variations in the feed to the column or because of the control range required for the instrument (5 dedegrees would seem to be a minimum for this range).

Step 3. For the extremes in the control point compositions, calculate the numbers of plates required between the control points and the ends of the column to insure pure end products. Convert from theoretical to actual plates.

The numbers of additional plates required to give a control range as obtained with this procedure increases with wider variations in the compositions encountered and also with increasing difficulty of the separations. It thus provides a rough means of obtaining a reasonable number for the extra plates. An easier if slightly less definite procedure, of course, is to simply estimate the numbers of extra plates required for control, and to add these to the numbers obtained in Step 1.

There is one argument against the concept of balance presented here that is indeed difficult to answer. In few engineering subjects has there been as heavy and continual an effort by as many experts over as long a period of time as in distillation. A very large number of publications have appeared on the subject treating both the underlying mathematics and the actual behavior of the columns. Under these conditions the confusions concerning and the general ignoring of a variable of such basic simplicity, widespread effects, and economic importance as the column balance would appear to be quite impossible. "Fantastic" is the unavoidable descriptive for this situation. Nevertheless it is the writer's careful certainty resulting from a number of years of awareness that the balance phenomena are as described here, that they have the full weight of importance given them, and that they can be organized for our reasoning in the manner presented. The concept of balance gives a clear, quick consistency to the behavior of the columns in a way other thought arrangements do not approach.

There remains the exceedingly interesting question as to the reasons this subject is so confused, why we do not know to deliberately control the columns for balance, and why we have failed to realize that our theory does not apply to the operating columns. The writer has been informed —and it seems quite reasonable—that in the period around the year 1910 the maintaining of the balance was the principal concern in distillation. It would be very interesting to follow the steps by which this idea was submerged and lost with succeeding mathematical developments.

Certain vague reasons for our present break between actual and theoretical can be lumped together under the terms "academic" and "prestige," and certainly the misdirections of the plate-to-plate approach have not helped. The control arrangements used have come from our elaborate theory rather than from the actual needs of the columns. And anyone that would question the basis of "constant conditions" would seem to be preferring confusion to order. A curious effect is that the chance of the balance, the accidental quality of it, has greatly helped to obscure the subject and prevent its organization. In addition, the interference of the column instruments prevents the balance from being any logical function of external changes. The single most difficult point seems to be the idea that impurities are continually forced into one or the other of the product streams, and that these impurities are independent of the number of trays (above a minimum) which may be present. And the reason for this difficulty is that our body of theory does not recognize such behavior, the columns in our design calculations are always nicely balanced. Also we have trouble with the idea that the two halves of a column represent two equal and independent material balances which must be controlled separately if we are to maintain the purity of both product streams. We tend to think that the complex interrelations that can be written around the feed zone rigidly tie together the two halves of the column, and this is wrong. We do not realize that the fact that a single heat balance can be written around both halves (around the column) is as meaningless as the fact that a single heat balance can be written around two separately controlled furnaces.

Nevertheless the question as to how this situation could have been allowed to continue must remain essentially unanswered to the writer. The reader to whom this paper seems an exaggeration of a minor control problem and to whom "constant conditions" is obviously the essential basis for any distillation theory or design is in a unique position to judge for himself the causes of this astonishing blind spot in our reasonings.

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More Cat Cracking Feed

This new treating method proposes the use of BF_3-Ether to remove coke formers and metallic constituents from crude.

THE CONCEPT that a catalytic cracking unit feed stock must be completely free from metallic constituents and "coke formers" is neither technically necessary nor economically sound. An economical way to obtain catalytic cracker feed is to achieve a balance between the reduction of these undesirable components and the recovery of the accompanying useful heavy oil. Here is a review of some of the philosophy of feed preparation which led to the discovery of a new process.

The concentration of coke formers in each increment of crude bottoms may be as shown in Figure 1. The first increment contains mostly coke formers, while subsequent increments contain less and less. At some percentage of removal (d) an optimum is reached. Any additional removal will carry away quantities of useful oil that are greater than the coke formers. For ordinary crude oil of 30-40° API the magnitude of d is usually less than 10 percent.

To remove less than 10 percent bottoms from an ordinary crude oil by vacuum distillation is impractical in most cases. Propane or solvent extraction requires large solvent to oil ratios, uses pressure operation, and is expensive. Therefore, some approach other than volatility and solubility differences of various components in the oil must be used.

Coke formers are asphaltenes and resins. It is generally agreed that the asphaltenes exist in the oil in a colloidal state and the resins act as protective colloids. By disrupting the colloidal equilibrium, the asphaltenes coalesce and separate out from the system. This is the basic principle of a new process for catalytic cracker feed stock preparation which is covered by U. S. patent 2,745,792.

Minute amounts of Boron Fluoride Ethyl Ether Coordination Compound are used to cause the asphaltenes to coalesce and separate as a lower layer. No heat nor pressure is required.

Typical results on a 38° API Saudi Arabian crude is given for an example. The crude is mixed intimately with very small volumes of Boron Fluoride Ethyl Ether Coordination Compound. The mixture is centrifuged or settled. The lower layer after recovery of chemical reagent for reuse is a soft asphalt with a softening point of 100 F. The properties of oils are much improved and are shown in Table 1.

Metals as catalyst poisons are cumulative in their effects. Catalyst makeup for mechanical losses however, dilute the poisoning effect and helps maintain activity. The optimum catalyst makeup rate depends on many factors. One of them is the price of the catalyst. It has been shown that using a cheaper catalyst at a higher makeup rate may give higher net returns.

Assume that we are going to charge an 18° API (331# per barrel) reduced crude treated by the new process to a catalytic cracker. The oil contains a total metals content of 15 ppm. Then at a catalyst makeup or replacement rate of 1.5 pounds per barrel the equilibrium metals concentration on the catalyst would be:

$$\frac{331 \times 15}{1.5} = 3310 \text{ ppm}$$

Catalytic cracking a 10.1 percent residuum of West Texas reduced panhandle crude at 50 percent conversion using a natural catalyst should yield the results shown in Table 2.

By charging a BF_3-Ether treated reduced crude through a catalyst with a 3310 ppm metals content, we actually are going to produce about 20 percent more gasoline than if we were to charge a gas oil fraction obtained from the same amount of reduced crude. Thus we are producing more gasoline plus extra hydrogen as a by-product. Also, because of the higher hydrogen yield, it is likely that the gasoline product will be more aromatic and more olefinic than ordinary catalytic cracked gasoline and, therefore, have a higher octane rating.

ACKNOWLEDGMENT

This article was prepared from excerpts of a paper by C. D. Shiah, Chinese Petroleum Corporation, as presented before the Western Petroleum Refiners Association meeting in Casper, Wyo., on September 21, 1956.

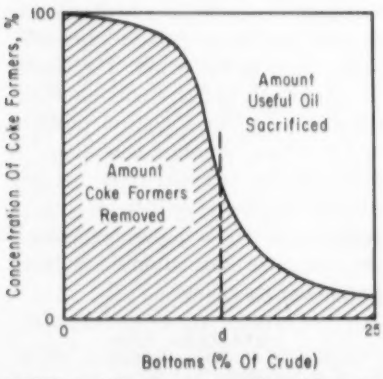

FIGURE 1—When large quantities of bottoms are removed, useful oil is lost.

TABLE 1
Treatment of Saudi Arabian Crude Oil

Volume % BF_3-Ether Used	Volume % Oil Yield	Specific Gravity at 28°C	Conradson Carbon Wt. %	Sulfur Wt. %
0	100	0.834	2.60	1.34
0.625	96	0.828	1.54	1.28
1.125	95	0.827	1.50	1.22
2.5	95	0.826	1.45	1.10

TABLE 2
Effect of Metals on Catalyst

Metals On Catalyst:	0 PPM	3310 PPM*
Yields Percent		
C_2 and lighter, cu. ft./bbl.	200	200
H_2, cu. ft/bbl.	50	325
C_3 and C_4 Olefin, Volume Percent	7.2	7.2
C_5 to 400°F. end point gasoline, Volume Percent	36.0	34.0
Carbon, Wt. Percent	13.4	15.6
Mol. Percent H_2 in Gas	20	62

*Yield estimated from a paper presented by Johnson, Eberline, and Denton at the ACS Division of Petroleum Chemistry Meeting, November (1955).

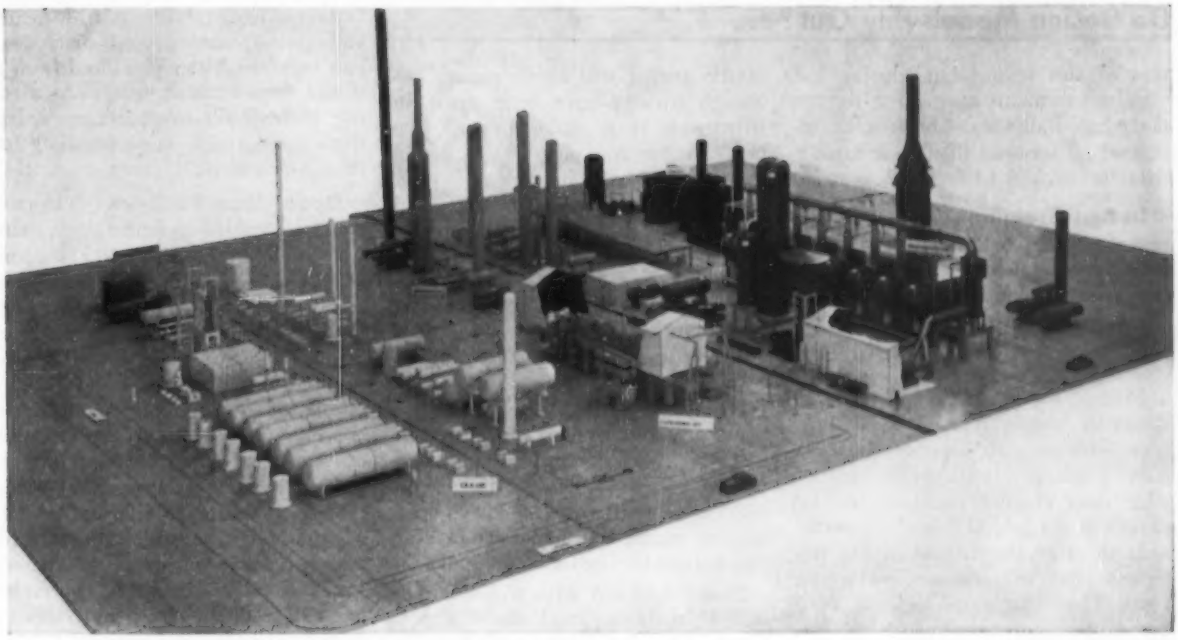

FIGURE 1—Plant-layout model: It shows up space requirements and general arrangement.

Do Models Pay Out?

Fluor has justified the costs of models on the design and drafting savings alone. Here's how models pay out for them.

Bruce L. Paton
The Fluor Corporation, Ltd.
Los Angeles

PRACTICALLY EVERY part of design is a three-dimensional problem. In spite of this fact, it has been the accepted practice to express the solutions with two-dimensional drawings. Even very capable engineers and constructors lose time in the translating process. Reference to several drawings is usually required before the translation is complete. There is also the possibility that the thought will suffer and omissions will occur in the translation. It is not practical to include each and every detail in the several views or drawings required to convey an idea on paper. This is the reason the visual design language common to every team member—scale models has been adopted.

It has been the universal comment of customers and their consultants that the designing of a job with the use of a model is a great timesaver for them. On a model, they are able to review in hours what previously would have required days. They have a much better feel of the job than they would have with nothing but drawings to work from. There is less misinterpretation of what is planned and, therefore, there are fewer changes in the later stages of design and after the plant is built.

A model is perhaps the only practical tool which enables a person to get all the key men concerned together at one time and expedite decisions and action. It was never possible to get a fair-sized group of people to sit down together and go over a set of drawings.

Not only do drafting and engineering benefit from the use of a model; other groups are also vitally interested in them. Quite often, we have foreign consultants and customers who are not too well versed in the English language. Even with the help of interpreters, it has sometimes been difficult to get technical ideas exchanged. On many occasions, we have utilized our models very successfully to bridge a language barrier.

Saving Drafting Expense—The only sure way of pinning down the value of a model is to use it in the design stage of a plant, and then compare costs against conventional drafting methods. This was done, and we now know that we can justify the cost of models strictly on a design and drafting basis if they are used during the design stage of a job.

With the use of models, both man-hours and calendar time has been saved in designing and constructing plants. During the first full year that Fluor used design models on every major job undertaken, drafting costs were $100,000 less than the previous year, and gross business for that year was slightly more. Granted, there were improvements in general drafting procedures to account for a por-

tion of this saving but, during the year, the company also issued, for the first time, individual isometric drawings of all screwed lines as a further construction aid to field forces.

Design Training—Through the use of models, better use is made of existing force of scarce, highly trained people to develop, easily and quickly, plants in model form. It is then possible to rely on lesser-trained people to complete the detailing.

Models are a definite aid to construction people. Not only is it possible with a plant-layout model to have a much more definite idea of what their erection problems will be earlier in the job, but they are better able to offer suggestions to the designers that will lessen construction costs. They can more logically plan the sequence of erection.

Saving Material—Building Better Plants—A model layout lends itself to reducing material costs. Most of the saving will be in piping, although savings have been made in structures. It is easier to pick the best routing for pipes on a model than it is on drawings. A supervisor can at a glance pick up a misrouted line before the error can be compounded. It has been found that this saves pipe and fittings. At one stage in model experimentation, a piping model of a complete refinery was constructed concurrently with piping-layout drawings. Doing the job in this manner, it was not too late to backtrack and change the drawings. On this job the company eliminated $50,000 worth of pipe, fittings, and fabrication that would not have been noticed except by the closer observation gained through use of the model.

Piping laid out with the aid of a model is shorter and more direct. Fewer pipe elbows are used. Friction loss is reduced, sometimes allowing use of the next smaller size pipe or reduced pumping horsepower.

Access to manholes, hard-to-reach valves, instruments, and machinery can be much better visualized from a model than from drawings. As a result plants built using design models show considerably more planning for operators and maintenance.

Model-Shop Facilities—When the company started its model shop, there was no experienced help to call upon. It was necessary to use those within the organization who had the know-how of plant design, plus some manual dexterity, to delve into this new three-dimensional medium. A couple of unused drafting tables plus some carving knives made up the available equipment. After the first few attempts, it was discovered that to do the job properly professional modelmakers had to be obtained and certain necessary machinery purchased. Facilities and manpower have been increased gradually until the company now has a 20-man crew of professional modelmakers. The shop contains close to $20,000 worth of equipment and stock. In addition to the

What Types of Models Are Used?

The following three types of models are used for design at Fluor: (1) Plant-layout model, (2) piping-layout model, and (3) piping-arrangement model (full scale). Each of these types serves a specific and different purpose in our work.

Plant-Layout Model—Figure 1 illustrates a typical plant-layout model. Notice its simplicity. With this model, the only interest is in the space requirements of the pieces of equipment and the general arrangment of the plant.

The plant-layout model was developed to serve as a focal point, a clearing house for plant design, coordinating the activities of the various specialists. In the design department, there are seven specialized groups: primary plant layout, structural design, structural drafting, vessels, piping, instruments, and electrical drafting. On tight schedules, coordinating their efforts for maximum efficiency becomes a big problem. Designing our plants in model form first allows each of these groups to have a composite picture of the whole job sooner. They can, therefore, get an earlier start on their detailed construction drawings.

How then do we go about developing a plot plan through the use of a plant-layout model? First, the process engineers furnish process-flow sheets and equipment specifications to all concerned. Mechanical-flow sheets are drawn. A rough sketch of the plot plan is drawn. The process units are indicated by blocks only. Equipment for the plant-layout model is made using preliminary outlines. The piping-layout designer then arranges the equipment to the best of his ability to suit the piping condition of the job.

Interferences may begin to show up at this point, or it may be necessary to change the over-all arrangements to secure a better plant. If this occurs, a fresh start is made. Here is where some of our measurable savings occur. It is easier and quicker to rearrange equipment on the model than on paper. Our plants have been more orderly and cleaner, from a design sense, since we initiated plant-layout models. It is considerably easier to build this orderliness into a model than it is on drawings. Possibly even more important is the fact that early approval of the layout on this model allows us to proceed to the next step in the design with less chance of change than we ever could with layout drawings.

Upon completion of this model a conference is held to approve the layout. A formal plot plan is then drawn of the approved arrangement shown on the model.

Piping-Layout Model—We have found that we can lay out a complete plant, including all piping, in approximately the same time as we could with the old paper drawing method.

The piping-layout designer starts the layout of the piping in the plant by first transposing the mechanical and utility-flow sheets to the plot plan drawing. This is to locate, generally orifice runs, control valves, widths of pipe-ways and general space requirements. The paper work is kept to a minimum. Meanwhile, pieces of equipment are being made by model-shop personnel for the model. All equipment operating together as a process unit is painted the same color to allow easy identification. Model equipment is given to the layout designer, who indicates the location of manholes, nozzles, platforms, and ladders on vessels and returns them to the modelmaker. The modelmaker drills the nozzles, mounts platforms, ladders, manholes, etc.

The equipment is then mounted on plot boards. The piping-layout designer directs, either verbally or with sketches, the modelmaker in routing the piping on the model. This is done in a temporary manner using materials which have flexibility and allow changes to be made easily and quickly. All piping is shown with 1/16 inch diameter brass rod, regardless of actual size. True OD of pipe is indicated with short lengths of rubber sleeving. Direction of flow, line number, specification, and insulation are indicated with plastic snap-on arrow-shaped line tags. These are placed on the lines as they are installed. Valves, orifice flanges, instrumentation, etc., are indicated by castings, which are slotted to fit on the brass rod.

While the modelmaker is installing pipe, the designer is working

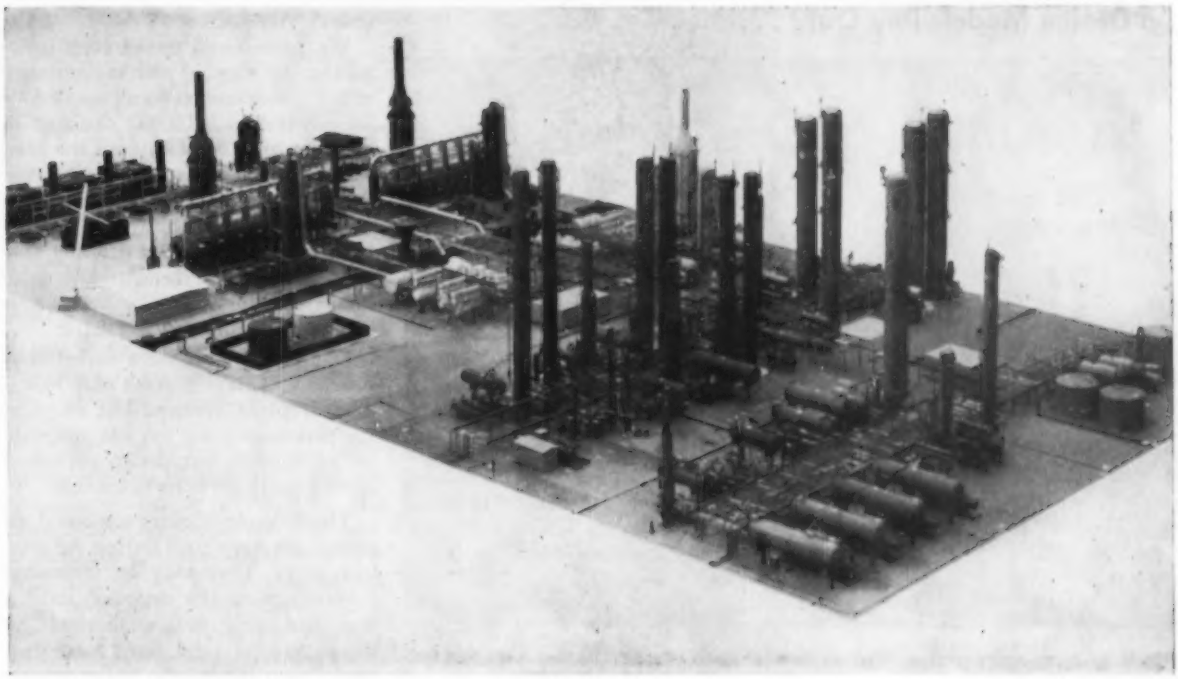

FIGURE 2—Piping-layout model: It can be laid out in the same time as the old paper drawing method.

out close fits on sketches for future use in making spools or arrangement drawings. He also is firming the location of working platforms, structures, etc., with the help and advice of the structural specialists.

During the period of installing pipe on the model, other design groups such as Electrical and Instruments are viewing the model and making sketches to locate their equipment. Racks for electric and instrumentation lines are installed on the model as the information is developed.

When the piping-layout model is complete, a formal job conference is held. Project, process, construction men, customer's representatives —all principals and key men concerned—are represented. Changes are agreed upon or approvals given.

A complete piping-layout model is shown in Figure 2. This model, built at a scale of ¼ inch = 1 foot, is 11 feet wide × 24 feet long. It is made in 14 sections for reasons of accessibility and handling. The scale of our models is dependent upon over-all plant size. Most common scales are ¼ inch = 1 foot and ⅜ inch = 1 foot. Occasionally we find it advisable to use a larger scale on congested sections.

Normal procedure after obtaining approval of the piping-layout model is to start a minimum number of piping-arrangement drawings. These, together with spool drawings and the model or photos of the model, are used by construction to erect the piping. By having the model in the field, the number of piping-arrangement drawings required, especially sections and details, has been reduced.

Piping-Arrangement Model—Figure 3 shows a piping-arrangement model. Note that piping is shown in true diameter as opposed to the 1/16 inch wire of the piping-layout model. This model was made after the piping-layout model. True-diameter piping gives field personnel a better feel of piping-erection problems and, together with photoplans, can eliminate piping-arrangement drawings and serve as a basic check of the spool drawings.

The equipment for this model is made from approved vendors' drawings. As each pipe spool is drawn, it is fabricated in wire or plastic by the modelmakers and installed on the model. If the piece fits, the spool is basically correct as to orientation and its basic configuration. The spool drawings are then given a fractional dimensional check and issued for fabrication. This method, when fully perfected, should utilize models to their greatest advantage.

Spools are normally drawn from formal piping-arrangement construction drawings. However, on one recent large job, the usual piping-arrangement drawings were eliminated and spooled directly from the piping-layout model. Photographs of the model with coordinates and basic dimensions added were substituted for the piping-arrangement drawings. The photographs are not ordinary ones but a type that can be duplicated on ozalid machines. The plan type is usually blown up to ¼ inch = 1 foot scale.

Estimated drafting time has been bettered with this method, and construction men indicate the idea will work well for them. It is felt that future jobs may result in even greater savings, once the spoolers have gained the experience at spooling directly from a model and photographs rather than from dimensioned piping-arrangement drawings.

There is a question often asked: Are we contemplating eliminating completely the usual piping drawings? The answer at the moment is no. However, it is known that for the past two years Procter & Gamble, Cincinnati, Ohio, a company in an allied field, has almost completely eliminated piping-arrangement drawings. Instead they have substituted models and reproducible, dimensioned photographs of the model.

There are many other drawings that will always be necessary to a job and cannot be eliminated by a model, such as foundation drawings, structural, electrical, instrumentation drawings, etc. In fact, when it comes right down to it, about all we hope to eliminate is a good percentage of piping drawings. Even if not a single formal drawing is eliminated, the drawings which are made are more accurate than they once were, and they are being done in less time.

Estimate Structural Model—In addition to pure design models, an estimate structural model is made frequently to help determine and show potential customers just what is proposed.

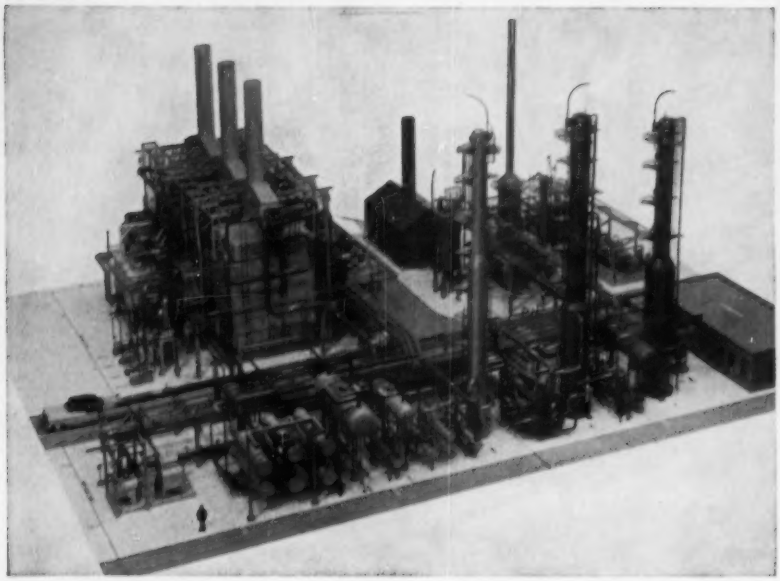

FIGURE 3—Piping-arrangement model: True diameter piping gives field personnel a better feel.

crew of 20 modelmakers, there are at least as many plant designers who are capable of doing their own piping layout with pliers and soldering irons.

There is a building of 8000 square feet of floor space designed specifically so that modelmakers and plant designers can work together. Drafting tables are within ten feet of the model assembly tables. Actually, during the past year, this space has not been nearly enough, and personnel has had to spill over into other drafting rooms. There are now models throughout the drafting areas where they are as much a part of our drafting-room equipment as pencils and drafting machines.

Disadvantages of Models—One of the drawbacks to models has been the fact that there is no simple way of duplicating them. Once a model has been made, there are usually demands that it be in several places at once. Through the efforts of company personnel and a professional photographer, this disadvantage is being eliminated. To date, results have been fair. In fact, first somewhat crude attempts have not only satisfied construction people, but have been applauded by them. The use of printable photographs, when fully developed, will, if nothing else, eliminate the drawing-in of background detail that is so time-consuming on standard arrangement drawings.

Another disadvantage of models is that they are difficult to ship. However, with the use of transparent crates, air freight transit with special handling at both points, this difficulty has been largely overcome.

Meet the Author

BRUCE L. PATON, design supervisor for The Fluor Corporation, Ltd., has been in charge of industrial model-making activities for the engineering-construction company since he joined the firm in July, 1954. Born on July 24, 1918, in Newburyport, Mass., Paton attended Massachusetts Institute of Technology. In his present position, Paton supervises 18 model makers, who build approximately 100 models each year. An important part of his work concerns development of new techniques and use of new materials in model design and construction. Paton lives with his wife, Edith, and their four children, in Alhambra, Calif.

What Do They Cost?

We have found model costs insignificant in view of the savings they entail. Using models on all major jobs amounted to $100,000 savings in drafting costs the first year the plan was used. This is a quite conservative figure and does not take into account the many benefits derived from models other than drafting savings. These other benefits are quite intangible—for example, how much is better coordination worth?

Our model costs have varied considerably. This is due not only to the type of plant involved but more to the personnel doing the job. Not only model builders but design personnel affect greatly the costs of models.

The following figures are based on models we have built during the past two years. They may be somewhat lower than can be expected until a firm has fairly well established the use of models and have their own model shop. Those who utilize outside model concerns to build models will find costs somewhat higher.

We have found that models of plants costing in the neighborhood of $1 million run us around .4 of 1 percent of the total costs or around $4000. This is our actual cost for labor and material (labor figured at $3.00/hr.). Material costs run less than 10 percent of the total costs, usually closer to 5 percent.

Models of plants costing in the neighborhood of $30 million run us around .05 of 1 percent of the total job costs or around $15,000.

Model costs of plants within the $1-$30 million range will vary accordingly. These costs cover all the models required for a particular job, usually either two or three; plant layout model, piping layout model and piping arrangement model. Occasionally we combine any two of these but our costs remain about the same. We may utilize the pieces and parts of our plant layout model in our piping layout model, or instead of making a piping arrangement model we may revise and add to our piping layout model to make it agree with our piping drawings before we send the model to the field.

Original presentation was before the Petroleum-Mechanical Engineering Conference of ASME, Dallas, September 23-26, 1956. ##

Use this method for . . .

Drainage Time of Bubble-Cap Columns

All you need to know are the physical characteristics of the trays and the viscosity of the liquid. This method works for any number of trays.

Frank J. Lockhart
Department of Chemical Engineering
The University of Southern California, Los Angeles

BUBBLE-CAP columns have weirs at the exit side of each tray to ensure a minimum height of liquid on the tray during operation. As a column is shut down, there would be a certain amount of liquid trapped on each tray (up to either the height of the weir or the risers, whichever is lesser), were it not for the weep holes. The weep holes permit the liquid to drain from each tray through all the trays below it and out the bottom of the column.

Weep holes are usually between ¼-inch and ½-inch in diameter. Smaller diameters are usually avoided because of the possibility of plugging the holes with solids.

If the total area of the weep holes in each tray is too large, too much liquid can bypass the bubble-caps during operating periods, causing a decrease in contacting efficiency. If the total area of the weep holes per tray is too small, excessively long times can be required to drain the column at the beginning of shut-down or turn-around periods. Bolles[1] recommends a design standard of about four square inches of weep holes per 100 square feet of tray area. This recommendation is presumably for typical weir heights and conventional liquid flow rates; it should be checked for possible by-passing effects in special cases of small liquid flow rates.

The specific problem of interest here is the calculation of the drainage time of a bubble-cap column, given the physical characteristics of the liquid and the column. In this article, a mathematical relation is derived from the standard flow equation and modified to represent more closely the limited amount of experimental data available.

Mathematical Considerations—In the drainage of liquids through weep holes, only the kinetic energy and the potential energy terms of the standard flow equation are of interest. Neglecting frictional effects for the moment, these energy terms simplify to:

$$u_o = \sqrt{2gx} \qquad (1)$$

which is the familiar Torricelli's Theorem. Introducing the multiplier C_o, the effective drainage coefficient, to account for frictional effects, Equation (1) becomes:

$$u_o = C_o \sqrt{2gx} \qquad (2)$$

Meet the Author

FRANK J. LOCKHART is head of the Department of Chemical Engineering at the University of Southern California, Los Angeles, Calif. Prior to this, Lockhart had eight years of industrial experience as process engineer with Humble Oil & Refining Company, and Union Oil Company of California, and as manager of Products and Development department, The Fluor Corporation, Ltd.

Lockhart holds a B.S. and a M.S. in chemical engineering from the University of Texas, and a Ph.D., from the University of Michigan.

Drainage from One Tray. Under falling head, where t is the time of drainage, $x = h$ at $t = 0$, and $X = x/h$,

$$u_o = C_o \sqrt{2gx_t} = \frac{-A_T\,dx_t}{A_o\,dt}$$

$$\frac{dx_t}{dt} = \frac{-A_oC_o\sqrt{2g}}{A_T}\sqrt{x_t} = -k\sqrt{x_t} \qquad (3)$$

and Equation (3) integrates to:

$$x_t^{1/2} = h^{1/2} - kt/2 \qquad (4)$$

$$\text{or, } (tk/h^{1/2}) = 2\,(1 - X_t^{1/2}) \qquad (5)$$

Equation (5) represents the relationship between X_t and t for the drainage of one tray.

Drainage from Two Trays. Where the time is measured from the start of draining of the top tray, and considering the two trays as identical, the volumetric material balance around the second tray shown in Figure 1, becomes:

$$\text{Output} - \text{Input} = \text{Depletion} \qquad (6)$$

$$\text{where, Output} = C_oA_o\sqrt{2g}\,x_2^{1/2}\,dt$$

$$\text{Input} = C_oA_o\sqrt{2g}\,x_1^{1/2}\,dt$$

$$\text{Depletion} = -A_T\,dx_2$$

Substituting in Equation (6) and rearranging,

$$\frac{dx_2}{dt} = k\,(x_1^{1/2} - x_2^{1/2}) \qquad (7)$$

Equation (7) may be integrated by substitution into the following general form: (details of this integration may be obtained from the author if desired)

$$2.303 \log 1/(X_3 - X_2^{1/2}X_1^{1/2} + X_4) =$$

$$(4/3)^{1/2}\left\{\arctan (4/3)^{1/2}\left(\frac{X_2^{1/2}}{X_1^{1/2}} - \tfrac{1}{2}\right) - \arctan (4/3)^{1/2}(\tfrac{1}{2})\right\} \qquad (8)$$

Equation (8) may be written in the following form:

$$0.2618 - \log (X_3 - X_2^{1/2}X_1^{1/2} + X_4) = 0.501 \arctan 1.155\left(\frac{X_2^{1/2}}{X_1^{1/2}} - \frac{1}{2}\right) \qquad (8a)$$

Equation (8) may be solved by

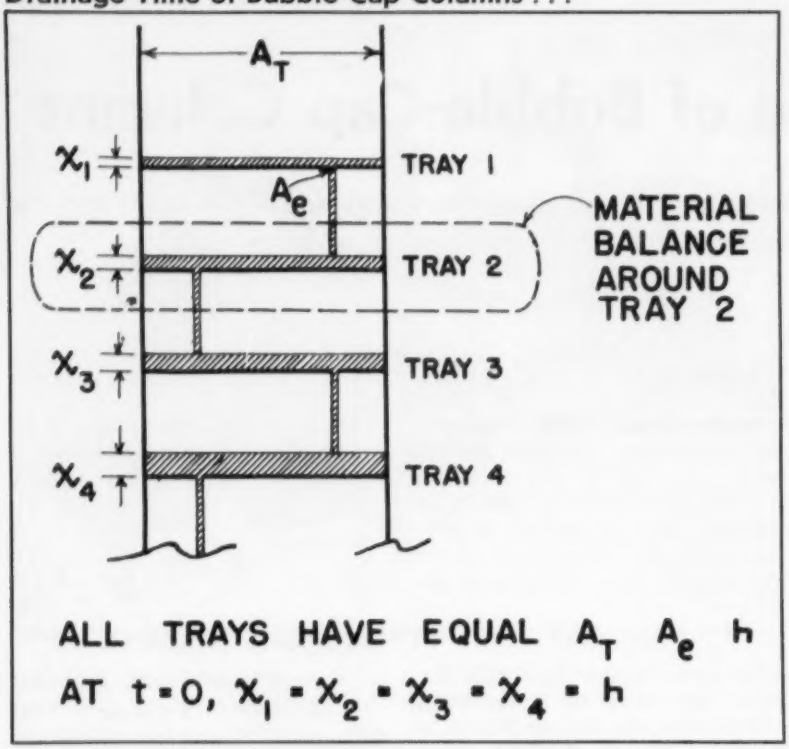

FIGURE 1—Schematic diagram of weephole drainage.

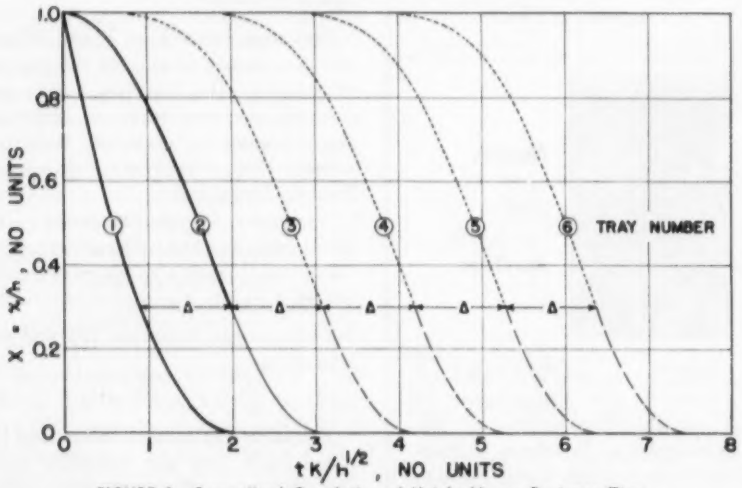

FIGURE 2—Generalized Correlation of Height Versus Drainage Time.

trial and error to obtain the relationship between X_1 and X_2. Table 1 gives some of these values.

TABLE 1
Solution of EQN. (8)

X_1	X_2
1.000	1.000
0.750	0.985
0.500	0.923
0.300	0.823
0.100	0.628
0.050	0.538
0.020	0.452
0.000	0.298

Equation (8) in combination with Equation (5) gives the relationships of $(tk/h^{1/2})$, X_1 and X_2. These are plotted as the heavy solid curves of Figure 2.

Under the assumed ideal conditions, when X_1 becomes zero, the top tray no longer can have any effect on the drainage of the second tray. The second tray should drain from X_2 of 0.298 to zero exactly as did the first tray, but displaced along the $(tk/h^{1/2})$ axis by an addition factor. This addition factor Δ is calculated by Equation (5) as the $(tk/h^{1/2})$ increment for X_1 to drain from 0.298 to zero, and is found to be 1.092. The complete drainage of two trays is given by:

$$(tk/h^{1/2}) = 2 + 1.092 = 3.092 \quad (9)$$

The light solid curve of Figure 2 completes the drainage of the second tray.

Drainage from Multi-Trays. On inspection of the solid curves of Figure 2, it appears reasonable to assume the same drainage characteristics of tray three as of tray two, between values of $X_3 = 0.298$ and zero; and so on for each succeeding tray. This assumption of a constant Δ between trays is shown by the dashed lines of Figure 2. Then, the idealized drainage-time relationship for a column of N identical trays is obtained from Equation (9) as:

$$(tk/h^{1/2}) = 2 + 1.092\,(N - 1) \quad (10)$$

The assumption of a constant Δ is consistent with the experimental observations.[2,3] Huitt and co-workers[3] specifically pointed out that the time intervals between emptying of two succesive trays was constant for any given liquid if the height at start of drainage was the same on each of the trays.

Although it is of no concern in this treatment of drainage times, the path of drainage from $X = 1$ to $X = 0.298$ may be obtained for tray three by assuming the same relationship between X_3 and X_2 as was derived for X_2 and X_1 (Equation 8); and so on for each succeeding tray. These are shown by the dotted lines of Figure 2.

Utilization of Idealized Relationship—Equation (10) is the drainage-time relationship under idealized conditions for bubble-cap columns. It consists of two terms: the drainage of a single tray, and the increment for each additional tray. The available experimental data are analyzed in view of these two terms to determine the values of C_e, the effective drainage coefficient, and to see if the slope of the $(tk/h^{1/2})$ vs. N line agrees with the theory.

Non-Ideal Effects. Two visible conditions which influence the drainage time are vortex formation and in-

complete drainage. Neither of these conditions can be predicted with accuracy. Leventhal[4] mentions the problem of vortex formation in the draining of a viscous mineral oil through weep holes of 3/8-inch diameter or less.

Huitt and co-workers pointed out that liquid remained on the tray after drainage had stopped for weep holes of less than 1/4-inch diameter, and that the residual height varied with the liquid and the size of the weep hole. They report about 3/16-inch of residual height of water remaining over a 1/16-inch diameter weep hole in a tray of 1/16-inch thickness. Figure 2 shows the importance of this residual height on the drainage time. For a single tray, the last 2 percent of height requires about 15 percent of the total draining time.

It would appear as if incomplete draining would reduce the drainage time, and that vortex formation would increase the drainage time. However, it is probable that both of these conditions are present to some extent in all drainings, so their net effect can not be predicted.

These two visible conditions and the nature of flow are affected by physical characteristics of the equipment, such as weep hole diameter, tray thickness, and weir height, and by physical characteristics of the liquid, such as density, viscosity, and surface tension.

Evaluation of C_e. The effective drainage coefficient C_e has been calculated from experimental data on single trays and Equation (5) assuming complete drainage. Figure 3 gives these results for water, and Figure 4 for mineral oil.

Figure 5 shows the variation in C_e with kinematic viscosity, for typical operating conditions of h between 2 inches and 6 inches, and d_e of 1/4-inch and 3/8-inch. The solid line represents the data to within about 25 percent. For 1/8-inch diameter weep holes, the values of C_e are about 10 percent higher than shown on Figure 5 for water, and about half the values on Figure 5 for mineral oil. The range of data shown reveals the approximate nature of drainage time calculations, even from one tray. Lack of data prevents evaluating the effect of surface tension, of incomplete drainage, and vortexing.

Incremental Drainage Time for Additional Trays. Equation (10)

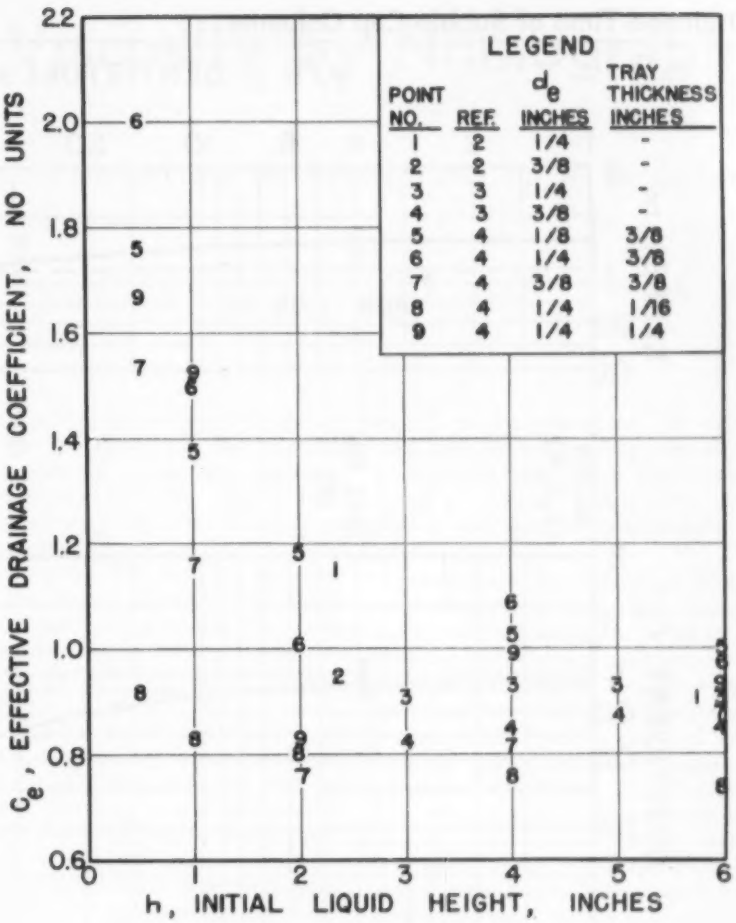
LEGEND
POINT NO. | REF. | d_e INCHES | TRAY THICKNESS INCHES
1 | 2 | 1/4 | -
2 | 2 | 3/8 | -
3 | 3 | 1/4 | -
4 | 3 | 3/8 | -
5 | 4 | 1/8 | 3/8
6 | 4 | 1/4 | 3/8
7 | 4 | 3/8 | 3/8
8 | 4 | 1/4 | 1/16
9 | 4 | 1/4 | 1/4
C_e, EFFECTIVE DRAINAGE COEFFICIENT, NO UNITS
h, INITIAL LIQUID HEIGHT, INCHES

FIGURE 3—Effective Drainage Coefficients for Water.

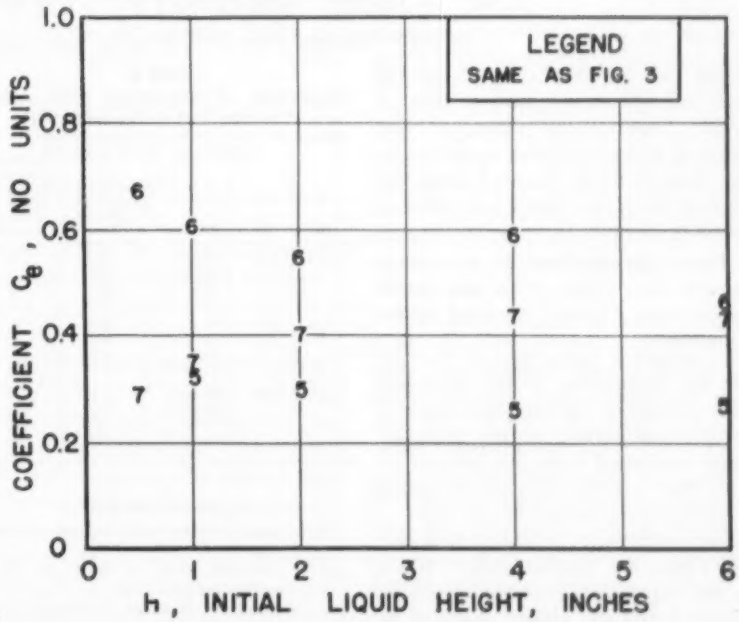

FIGURE 4—Effective Drainage Coefficients for Mineral Oil.

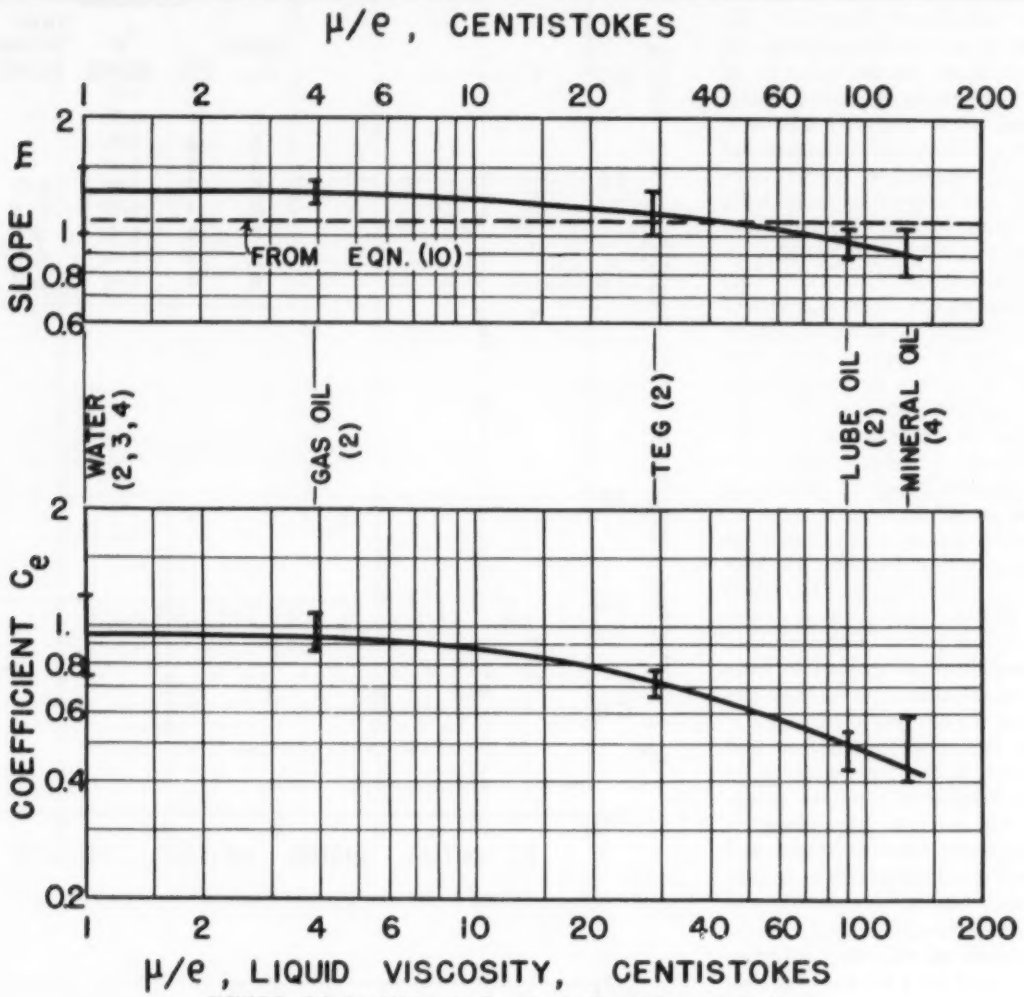

FIGURE 5—Calculated Values for C_e and m for Typical Operating Conditions.

shows that a plot of $(tk/h^{1/2})$ versus tray number should have a slope of 1.092. Experimental values of the slope of drainage curves as plotted in the upper part of Figure 5 show deviations from this theoretical value of about ± 25 percent.

Final Correlation—It is recommended that values of C_e and m obtained from Figure 5 be used in the equation:

$$(tk/h^{1/2}) = 2 + m\,(N - 1) \qquad (11)$$

for an estimation of the drainage time of bubble-cap columns. Table 2 gives a comparison of the drainage times calculated from this correlation with the original data of Broaddus et al for the drainage of six trays.

For conservative estimates of drainage times, the smaller values of C_e in the experimental range shown in Figure 5 and the higher values of m should be used.

TABLE 2
Comparison of Correlation With Actual Drainage Time of Six Trays (2)

d_o	h	Liquid	Observed Drainage Time, Sec.	Percent Deviation of Correlation From Observed
¼"	2¼"	Water	218	20.
		Gas Oil	239	7.
		TEG	290	9.
		Lube Oil	386	7.
¼"	5¾"	Water	394	6.
		Gas Oil	409	4.
		TEG	489	3.
		Lube Oil	641	2.
⅛"	2¼"	Water	117	0.
		Gas Oil	127	—7.
		TEG	150	—7.
		Lube Oil	187	—2.

NOMENCLATURE

A_o — area of weep holes, square feet per tray
A_T — effective area of tray, = V/h, square feet per tray
C_e — effective drainage coefficient, dimensionless
d_o — diameter of weep hole, inches
g — acceleration of gravity, taken as 32.2 ft./sec. sec.
h — initial height of liquid on tray, feet
k — by definition, equal to $(A_oC_o\sqrt{2g/A_T})$
N — number of trays in column
m — slope of $(tk/h^{1/2})$ vs. N line
t — drainage time, seconds
u_o — velocity through weep hole, ft./sec.
V — volume of liquid at time zero on tray, cubic feet/tray
X — by definition, equal to x/h
x — height of liquid on tray at any time t, feet
Δ — increment of $(tk/h^{1/2})$ between emptying of successive trays, dimensionless
μ — viscosity of liquid being drained, centipoises
ρ — density of liquid being drained, gm./cc.

Subscripts 1, 2, etc. refer to tray number, counting from the top down.

LITERATURE CITED

[1] Boles, W. L., *Petroleum Processing*, 11-3: 82 (1956).
[2] Broaddus, Morse, and Huntington, *Pet. Engr.*, 27-2: C-38 (1955).
[3] Huitt, Ziegenhain, Fowler, and Huntington, PETROLEUM REFINER, 28-11: 143 (1949).
[4] Leventhal, E., M. S. Thesis in Chem. Engr., Univ. Southern California, Aug. 1951.

Find Absolute Viscosity by Nomograph

Absolute viscosity versus temperature for hydrocarbons up to 20 carbon atoms is quickly picked off this nomograph.

John Lohrenz
Engineering Research and Development Laboratories
Fort Belvoir, Va.

AN IMPROVED viscosity nomograph for a large group of hydrocarbons for temperature ranges extending from the melting to the normal boiling point with an average error of only 2½ percent and a maximum error of less than 5 percent has been constructed using the data from API Research Project 44.

Other nomographs representing viscosity-temperature data have been based on the observation that a plot of the logarithms of the absolute viscosity versus the logarithms of the absolute temperature is a straight line. For such a straight line relationship, a nomograph of two parallel scales and a point for each substance may be constructed. One scale will be logarithmic viscosity and the other will be logarithmic absolute temperature. The intersections with the viscosity and temperature scales of straight lines through a point for a particular substance will give the viscosity-temperature relationship.

Since the logarithmic plot is actually a slight curve, such nomographs are necessarily restricted to limited ranges of temperature. Extrapolation beyond these small temperature ranges yields grossly erroneous results. For example, a nomograph for the viscosity-temperature dependence of the homologous series of 20 normal paraffins from methane to n-eicosane for the temperature range from the melting point to the boiling point, constructed on the assumption of the best straight line through the logarithmic viscosity-temperature plot, would have average errors of 12 percent and maximum errors of 50 percent.

The large reduction in errors for the newly constructed nomograph was effected by modifying the logarithmic viscosity scale. The temperature scale remained the conventional logarithmic absolute temperature scale. The viscosity scale was developed for the 20 normal paraffins from methane to n-eicosane by a graphical trial-and-error method to find the minimum average error possible for the range of temperatures from the melting to the boiling point. The final average error of 2½ percent approaches the limits of the accuracy in reading the viscosity scales, and is believed to be sufficient for most engineering calculations.

Using the viscosity and temperature scales developed by this method and the viscosity data from the API research project, it was subsequently found that points which would reproduce the viscosity data for numerous other hydrocarbons could be located. The data for branched paraffins; isobutane, isopentane, and neopentane; could be represented. Even some aromatics and unsaturated hydrocarbons could be represented, e.g., cyclohexane, benzene, and ethene. Points for these hydrocarbons have been represented on the nomograph. In each case they reproduce the viscosity-temperature relationships throughout the range of the API data with accuracy at least equal to that for normal paraffins.

Furthermore, the nomograph is not restricted only to those compounds placed on the nomograph. Points representing the viscosity data of other hydrocarbons with an average error no higher than 2½ percent have been located by the intersections of the straight lines connecting two given viscosity-temperature relationships. The data for some additional normal olefines, normal and isomeric alkyl benzenes, normal alkylcyclohexanes, and normal alkylcyclopentanes have been reproduced by the nomograph, for the entire range of the API data. It seems reasonable, also, that other isomeric paraffin viscosity data which are not contained in the API data could be reproduced by the nomograph. The nomograph does not appear to be satisfactory for the range from the melting to the boing point within the limits of the 2½ percent average error for alkyl aromatics when the alkyl group contains more than twelve carbon atoms. Attempts to reproduce viscosity data of compounds other than hydrocarbons have been unsuccessful.

This nomograph is accurate within a 2½ percent average error for this data. The utility of the nomograph is limited to the temperatures of the API data, which ranged approximately from the melting to the boiling point for most compounds. Extrapolation beyond these temperature ranges for any compound is possible, but the chance of error will increase with the length of the extrapolation.

See Nomograph on Page 170

Meet the Author

JOHN LOHRENZ is presently a member of the U. S. Army stationed at Ft. Belvoir, Va., doing engineering research and development for the camouflage branch. He received his B.S. degree in chemical engineering from Kansas State College in 1952, and his M.S. degree in chemical engineering in 1954 from Oklahoma University. He worked one year in process development with the Ethyl Corporation at Baton Rouge, La., and plans to return to college to work on his Ph.D. upon separation from the Army.

Find Absolute Viscosity by Nomograph . . .

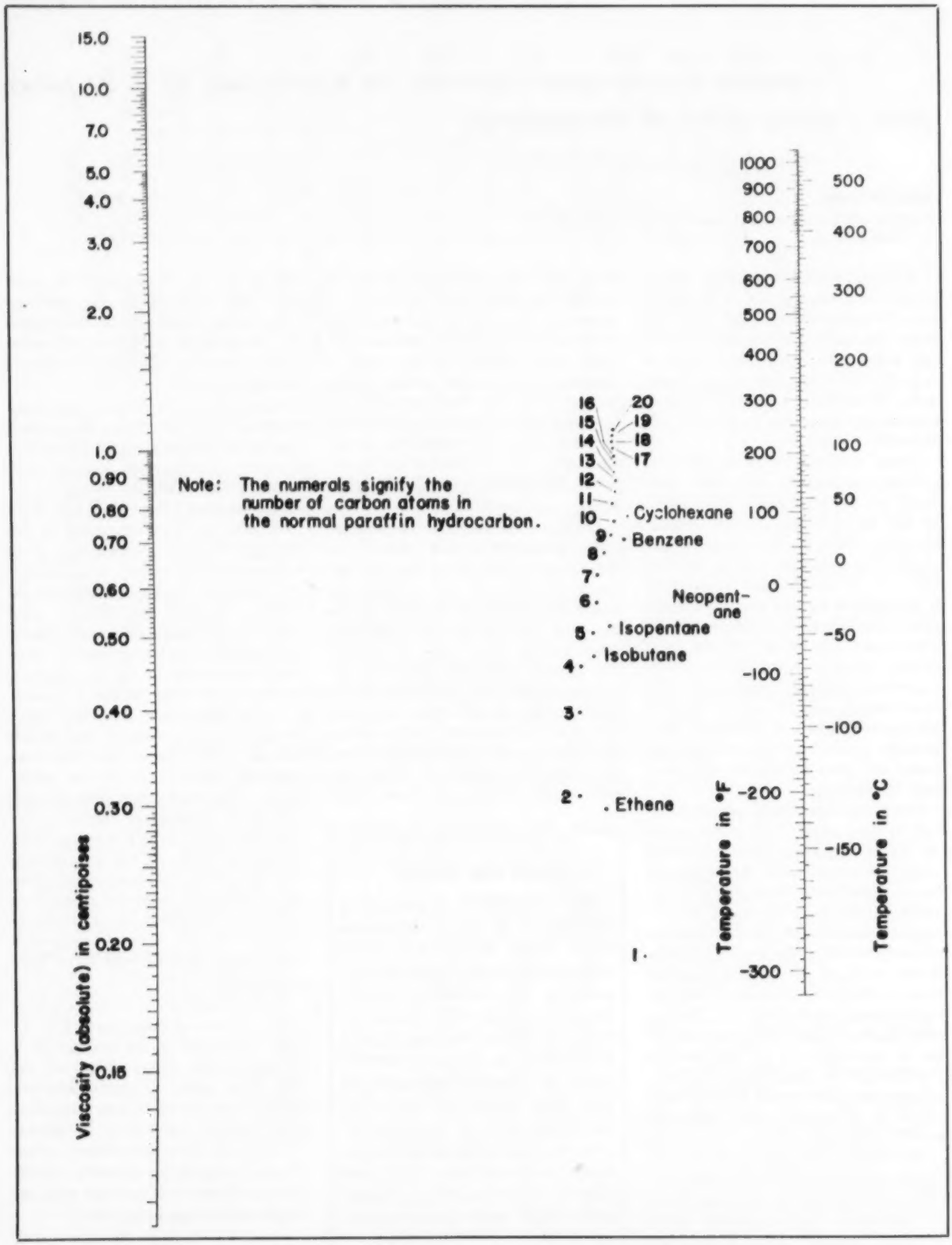

FIGURE 1—Viscosity-temperature nomograph for hydrocarbons.

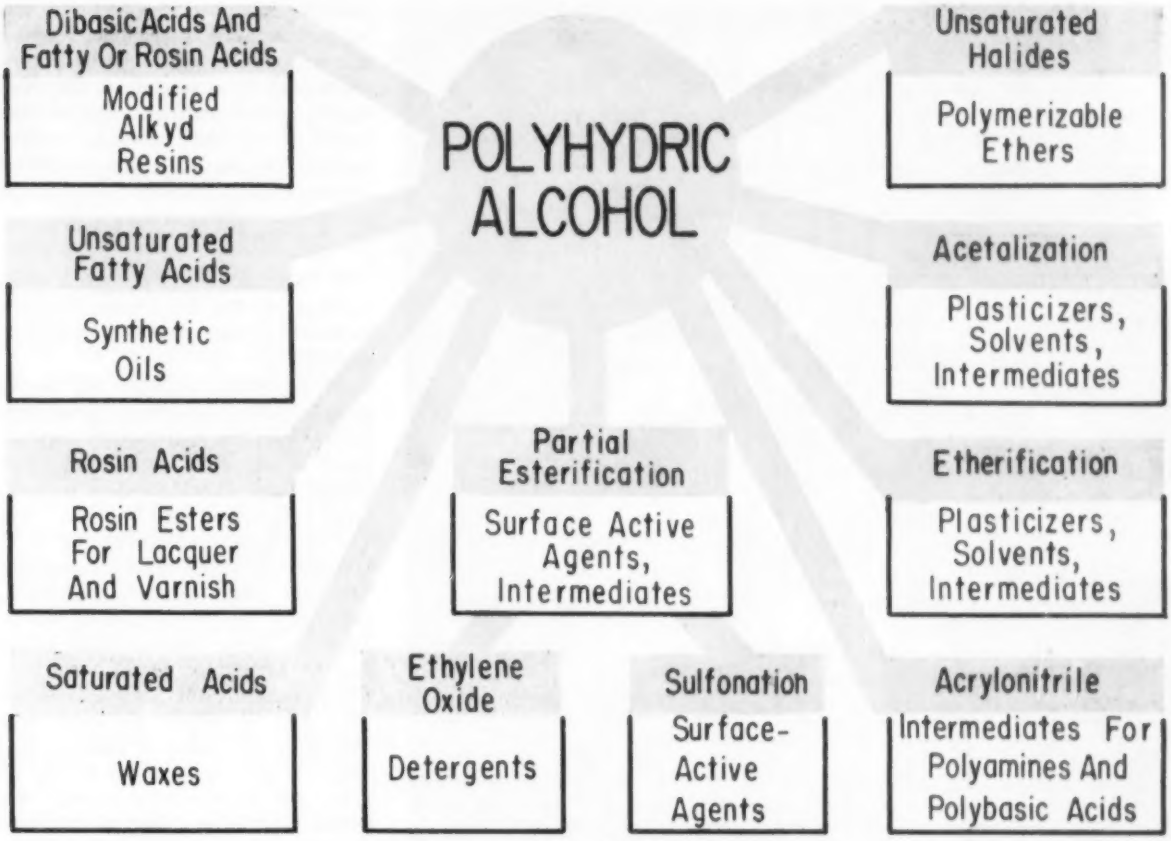

FIGURE 1—Types and uses of the Polyhydric Alcohols.

Here's the Complete Story on This Petrochemical . . . Pentaerythritol

Production, raw materials, reaction conditions, recovery stages, and uses are presented in this complete article on this useful polyhydric alcohol.

Peter W. Sherwood, Chemical Engineer
White Plains, New York

PENTAERYTHRITOL is, above all, a product of the petrochemical industries. It is manufactured by the reaction of one mole acetaldehyde with four moles formaldehyde and is, indeed the second-largest consumer of formaldehyde.

Both of pentaerythritol's parent compounds are derived predominantly from petroleum sources. Of the 31 formaldehyde plants (owned by 19 companies) in the U. S., 28 use methanol as raw material. Today, the bulk of methanol is, of course, produced from natural gas (via carbon monoxide and hydrogen). The three remaining plants, which account for some 12 percent of the U. S. formaldehyde output, employ direct partial oxidation of light hydrocarbons (principally butane) as their route to the production of formaldehyde.

The same three partial oxidation plants also obtain *acetaldehyde* as coproduct. This direct petrochemical synthesis route accounts for nearly one-quarter of the nation's acetaldehyde capacity. Another 60 percent of the acetaldehyde output is based on

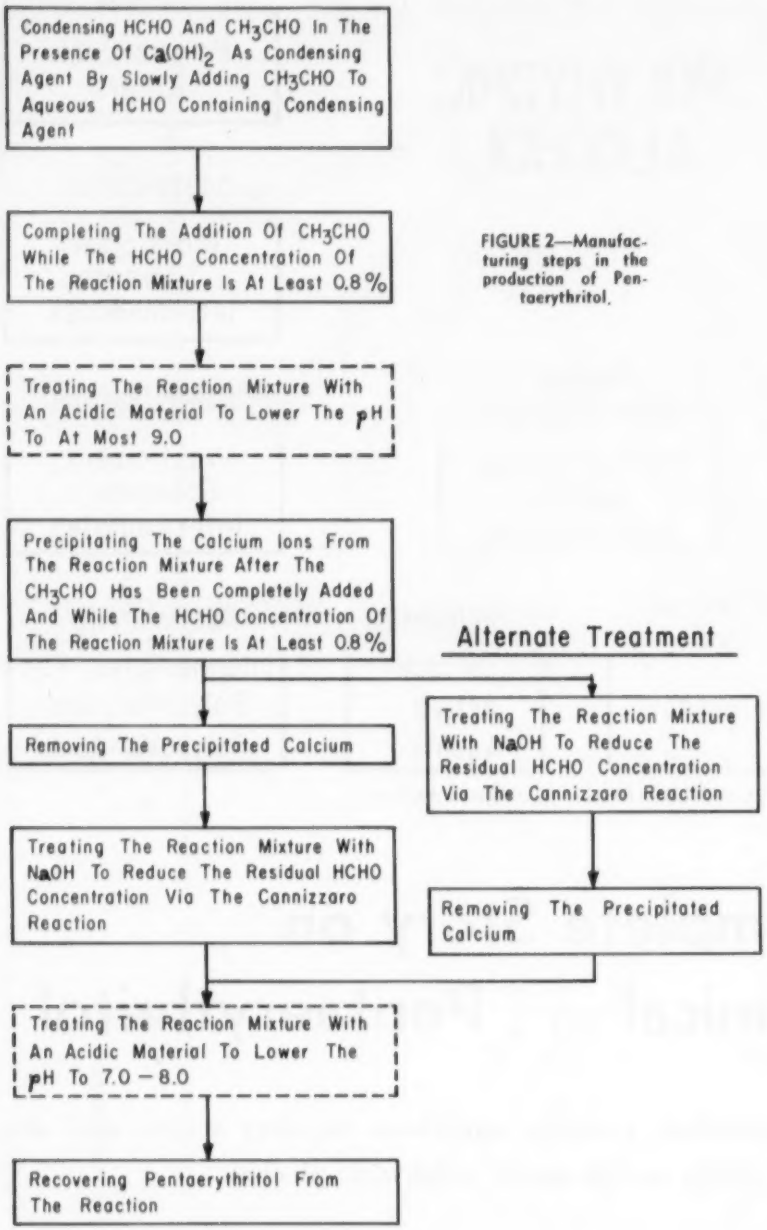
Condensing HCHO And CH_3CHO In The Presence Of $Ca(OH)_2$ As Condensing Agent By Slowly Adding CH_3CHO To Aqueous HCHO Containing Condensing Agent
Completing The Addition Of CH_3CHO While The HCHO Concentration Of The Reaction Mixture Is At Least 0.8%
Treating The Reaction Mixture With An Acidic Material To Lower The pH To At Most 9.0
Precipitating The Calcium Ions From The Reaction Mixture After The CH_3CHO Has Been Completely Added And While The HCHO Concentration Of The Reaction Mixture Is At Least 0.8%
Removing The Precipitated Calcium
Treating The Reaction Mixture With NaOH To Reduce The Residual HCHO Concentration Via The Cannizzaro Reaction
Alternate Treatment
Treating The Reaction Mixture With NaOH To Reduce The Residual HCHO Concentration Via The Cannizzaro Reaction
Removing The Precipitated Calcium
Treating The Reaction Mixture With An Acidic Material To Lower The pH To 7.0 – 8.0
Recovering Pentaerythritol From The Reaction

FIGURE 2—Manufacturing steps in the production of Pentaerythritol.

conversion of synthetic (ethylene-derived) ethanol, leaving the remaining 15 percent to production from fermentation alcohol and from acetylene.

Manufacture of pentaerythritol (PE) is an attractive means for upgrading formaldehyde. All but one of the nation's producers of PE are basic in formaldehyde.

Construction projects now underway promise to boost PE manufacturing capacity from 77.5 million pounds per year in 1955 to 141 million pounds per year in 1957. On the basis of short-range demand, this will establish large overcapacity. But justification for this extensive building activity rests in the long-range market outlook for PE, one of the spectacular growth chemicals of the 1950's.

During World War II, PE found important use in the production of the explosive pentaerythritol tetranitrate. But in a peacetime economy, this market is quite negligible. Instead, the bulk of PE enters into the production of resins (mainly of the alkyd type), surface coatings, etc. One estimate[1] shows the following market pattern for the 1955 pentaerythritol output:

Resins, surface coating	94%
Explosives	1%
Other	5%

(Of the total, 10 - 12 percent is monopentaerythritol, 1 - 2 percent dipentaerythritol, and the remainder technical PE).

In its major market, PE enters principally into resin-forming esterification reactions (particularly with dibasic acids, such as phthalic and maleic) and into alcoholysis reaction with unsaturated oils (notably tung oil). In these applications, PE is in competition with—and complementary to—other polyhydric alcohols, principally glycerine and sorbitol. Each of these intermediates offers specific advantages to the resin producer, but there is a large overlapping area in which the user may shift from one polyol to another, dictated largely by considerations of price and immediate product demand. The wide range of applications for the family of polyols is illustrated in Figure 1.

Among polyhydric alcohols for the resin and surface coatings industries, glycerine was in unchallenged position until the late 1940's. Since 1946, PE has found a rapidly growing market in this field. This has been partly due to expansion of ultimate consumer demand for surface coatings of the alkyd type, but beyond that, the acceptance of PE—and more recently of sorbitol—has made important inroads into the market for glycerine. Output of the three principal polyhydric alcohols developed, during the 1950's (millions of pounds), as follows:

	Glycerine	Pentaerythritol	Sorbitol
1950	223.0	36.4	7.5
1951	211.0	45.4	22.5
1952	188.0	41.0	50.0
1953	215.0	56.3	60.0
1954	207.9	53.7	70.0
1955	228.0	65.0	n. a.

For PE, a 1956 potential of 76 million pounds and a possible 90-million-pound output by 1957 is forecast.

It is believed that the competitive situation between the three principal polyols has, by now, become stabilized. The relative merits of the differ-

ent intermediates to the resin maker have become well defined on technological grounds (see below) and it is expected that, in the future, there will be less extensive switching from one polyol to another.

This aspect is, of course, also related to the price picture. Sorbitol's low cost makes it attractive and has been responsible for its fast growth, but its use is severely limited by performance deficiencies.

During the last decade, the price of PE has varied from 27.5 cents to 34 cents per pound. During the same period, there have been wide fluctuations in the price of glycerine, from a minimum of 17.5 to a maximum of 55 cents a pound. To the resin maker, the price stability of PE has been an important attraction. However, it may be expected that this advantage will disappear with the current outlook for price stability in the glycerine picture. Here, the stabilizing factor is the rapid growth of synthetic glycerine capacity which exceeds today 50 percent of the nation's demand (the first synthetic glycerine plant was taken on-stream in 1949).

What is said here regarding price per unit weight is also substantially true on an equivalent weight basis. Glycerine has a "combining" weight of 31, while that of pure PE is 34.

For a proper understanding of PE's position and potential in its competitive market, it is necessary to consider briefly the advantages—and drawbacks—of PE itself and of its principal alternate polyols for the production of resins and surface coatings.

Pentaerythritol occupies a unique position among the chief polyols in that all of its (four) hydroxyl groups are primary, and none of them is subjected to steric hindrance. This permits formulation of resin esters in a short cook time and the obtainment of a product of low acid number, using only as little as 10 percent excess polyol.

Pentaerythritol *drying oils* are characterized by excellent gloss, flexibility, durability, hardness, and by short drying time.[2] An outstanding advantage of PE over glycerine is its usefulness to form drying oils from such semi-drying oils as soybean oil. This permits also the production of non-yellowing finishes.

High durability and rapid drying also characterize *alkyd resins* based on PE.

FIGURE 3—In these centrifuges, crystallized pentaerythritol is separated from the mother liquor.

Glycerol has wide variety of uses outside the surface coatings industry —more than 1500 uses have been listed for this trihydric alcohol. It is only in the specific field of surface film intermediates that glycerol has met significant competition from PE.

The important advantage of glycerol is that it is a trihydric alcohol. This is of significance because in the production of polyesters (e.g., oil-modified alkyds), chain-branching must be avoided. This condition makes it necessary that *not* **more than two** hydroxyl groups be available for polyesterification, while the remainder is used for linking the drying oils. Arnold[3] points out that, even with glycerine, chain branching can occur with alkyds containing less than 61 percent oil. With increasing functionality of the alcohol, the likelihood of chain-branching rapidly increases. Thus, the primary demand of the resin industry is for the trihydric alcohols, among which glycerol is the most readily available. The tetrahydrics such as PE, are specific for the production of "long-oil" alkyds.

The chief disadvantage of glycerine drying oils is their relatively long drying time. Furthermore, unlike PE, glycerine's usefulness in conjunction with "semi-drying" oils is limited.

Sorbitol, a hexahydric alcohol ($CH_2OH - CHOH - CHOH - CHOH - CHOH - CH_2OH$) is obtained by the catalytic reduction of glucose, an agricultural product. A chief attraction of sorbitol is low price at which it is available. But it has an important drawback in the thermal instability of its four secondary functional groups which tend to split out water. In the production of alkyd resins and other esters, sorbitol is almost always used in conjunction with other polyhydric alcohols such as glycerine or PE. The usual procedure is to react sorbitol with more than stoichiometric requirements of acid and then to react residual acid with a more stable polyol at higher operating temperature.

Certain advantages, notably relat-

ing to hardness, have been claimed for sorbitol-based resins by virtue of internal ether linkages which are formed in the course of dehydration of the secondary functional groups.

TMC (2, 2, 6, 6-tetramethyl cyclohexanol) is a cyclic alcohol with five functional —OH groups, only one of which is secondary. Because of this secondary group, the material is also subject to thermal dehydration, an objection to which we have referred in the discussion of sorbitol. Actually, however, internal dehydration of TMC is observed only in esterification with phthalic anhydride. The trouble is not encountered in the production of alkyd resins based on maleic anhydride.

TMC is manufactured from cyclohexanone and formaldehyde. Thus, it is seen to be entirely derivable from petroleum sources. TMC may be esterified with fatty acids to yield reconstituted oils which form films of outstanding hardness. Drying time of such oils is faster than that obtained with corresponding glycerides. It is about equal to the drying time of similar PE-based oils.

Polypentaerythritols are highly functional alcohols obtained as byproducts in PE synthesis. An outstanding attraction of these polyhydric alcohols, is their usefulness in the alcoholysis of inexpensive oils such as soybean or tall oil, in grades which, because of their low functionality, cannot be treated with the more standard polyols to yield fast-drying coatings (varnishes).

Three more polyhydric alcohols, now available on a limited scale, have attracted recent interest in the paint and varnish industries:

Diglycerol ($CH_2OH - CHOH - CH_2 - O - CH_2 - CHOH - CH_2OH$) is today available on a limited scale only. The material, derived from glycerine, is thermally stable despite its two secondary alcohol groups. One source[2] reports that tests to date show this material greatly superior to glycerol as a protective coatings intermediate.

Inositol, obtained from corn steep liquors, is a cyclic hexahydric alcohol. Derived reconstituted oils dry faster than do PE oils. Inositol is of interest also because it permits use of fairly simple formulation procedures.

Trimethylol ethane and trimethylol propane are of interest in that they combine the advantages of being trihydric alcohols and of having only primary —OH groups. Both compounds are available on a limited commercial scale. Unit cost, and a relatively high "combining" weight have militated against their wide acceptance so far.

Trimethylol propane is produced by the condensation of one molecule butyraldehyde with two molecules formaldehyde in the presence of alkali. A similar condensation of propionaldehyde with formaldehyde yields trimethylol ethane.

These are the principal polyhydric alcohols which are available, actually or potentially, to the resin producer. As we have seen, pentaerythritol has established its definite position in this field by virtue of its tetrahydric character, the absence of secondary hydroxyl groups and the resulting desirable characteristics of many derived surface coatings, as well as by its attractive price and price stability.

Pentaerythritol Manufacturing Processes—The growing market for PE in the U. S. is supplied by eight producers. Details of their manufacturing processes differ but the overall production scheme follows the lines to be considered in this discussion.

Underlying the synthesis of PE is the reaction of one mole acetaldehyde with four moles formaldehyde. The reaction proceeds in two stages, a condensation to pentaerythrose followed by a Cannizzaro-type oxidation-reduction reaction to pentaerythritol.

$$3HCHO + CH_3CHO \xrightarrow{\text{alkali}} C(CH_2OH)_3CHO$$

$$HCHO \xrightarrow[\text{alkali}]{} HOCH_2-\underset{\displaystyle CH_2OH}{\overset{\displaystyle CH_2OH}{\overset{|}{\underset{|}{C}}}}-CH_2OH + HCOOH \quad \text{(as salt)} \qquad \ldots\ldots\ldots\ldots (1)$$

At synthesis conditions, both reactions occur without intermediate isolation of pentaerythrose. The conversion is carried out in aqueous medium. Calcium hydroxide is the usual condensing agent, but sodium hydroxide has also been employed. Following completion of the reaction, PE is crystallized from the medium following suitable adjustment of conditions as will be described below.

The objective in commercial synthesis must be to procure PE in maximum yield comparable with requirement on the product for high monomer content, good color and phthalate color, low ash and high hydroxyl content. Because of the reaction's complexity, these objectives are difficult to achieve and considerable work has been done, especially since 1940, which has established optimum conditions for the reaction proper and for the pentaerythritol recovery step.

In simple outline, the reaction is carried out by mixing acetaldehyde and formaldehyde with an aqueous slurry of lime. The agitated mixture is held, usually between 40 and 50 C. The time for the main reactions varies depending on numerous operating variables. At conditions which are employed commercially today, 1½ hours might be cited as typical.

Toward the end of the reaction period, a sudden rise in temperature is observed. This phase, referred to as "second reaction" or "caramelization" is accompanied by a yellowing of the solution. It is essential to the yield and purity of the product that the second reaction be permitted to take place. But there is no need to continue batch time much beyond the onset of the second reaction.

At this stage, therefore, the batch is prepared for product recovery. For this purpose, calcium is precipitated, usually by the addition of sulfuric acid. Following filtration, the clear liquor is concentrated by vacuum evaporation and this is followed by cooling and crystallization, and separation of PE. As many as three successive crops of PE may be recovered. Alternately, the primary mother liquor may be partly recycled to the reaction stage.

The reaction is accompanied by the formation of numerous byproducts (dipentaerythritol as well as others to be listed below). Furthermore, excess formaldehyde is present at the completion of the reaction step, and formic acid is released in the course of acidification (calcium precipitation). These contaminants are objectionable not only because of their effect on product purity but also because they lead to the formation of a syrupy medium from which PE crystallization is difficult if not impossible. Control of operating variables is therefore bent (a) toward minimization of byproduct

formation, and (b) toward destruction or removal of syrup-forming contaminants prior to the recovery step.

Among principal operating variables in the production of PE, the following must be recognized:

A. Raw Materials
1. Form, concentration, and purity of formaldehyde
2. Form of acetaldehyde
3. Condensing agent

B. Reaction Conditions
1. Method of addition
2. Feed ratio of components
3. Reaction time and temperature
4. pH control
5. Final formaldehyde concentration
6. "Second reaction"
7. Special aids for the Cannizzaro reaction

C. Recovery Stage
1. Elimination of residual calcium
2. Nature of impurities and their removal
3. Finishing conditions

It must be recognized that not all of these operating variables enter into each individual PE production process. Rather, these are the control methods by which different manufacturing methods yield, or are claimed to yield, the maximum amount of specification-grade PE.

Operating Steps to Watch . . .

Raw Materials
- **Formaldehyde**
- **Acetaldehyde**
- **Condensing agent**

Reaction Conditions
- **Method of addition**
- **Feed ratios**
- **Reaction time and temperature**
- **pH control**
- **Final formaldehyde concentration**
- **The "second reaction"**
- **Special aids for the Cannizzaro reaction**

Recovery Stage
- **Elimination of residual calcium**
- **Nature of impurities and their removal**
- **Finishing conditions**

A. RAW MATERIALS

1. Formaldehyde

Formaldehyde is most commonly marketed as 37 wt. percent aqueous solution (formalin). Much more limited quantities of more concentrated product, running as high as 50 percent, are available. Of the three grades, only the uninhibited material (containing less than 1 percent methanol) is of interest to the PE producer. Inhibited formaldehyde (containing 7 percent or 12-15 percent methanol, respectively) need not be considered in this connection. In recent years, there has been increasing traffic in paraformaldehyde, the trimer of formaldehyde which can be shipped substantially water-free and which is of potential interest to PE producers without near-by formaldehyde source.

Wyler[4] reports that methanol has an objectionable effect on PE yield. His work indicated that formaldehyde grades containing 0.5-1.0 percent methanol yield 80 percent PE at conditions where the presence of larger amounts of methyl alcohol (more than 4 percent) restricted the yield to 65 percent. Since the formaldehyde available today as uninhibited grade has a maximum methanol content specification of 1 percent, and normally contains between 0.5-0.6 percent of this alcohol, it is a suitable raw material for PE production.

In another patent,[5] Wyler reports that light transmission is an important criterion for formaldehydes of high reactivity in PE synthesis. He finds it desirable that the formaldehyde have a light transmission of 80-85 percent for 320 millimicron light. Such raw material permits feasible reaction rate at temperatures as low as 30 C. The advantage of operating at low temperatures is the reduction in by-product formation.

Another claim to high reaction rates is made for formaldehyde obtained by the direct oxidation of light hydrocarbon (which is practiced today by Celanese Corp., by Warren Petroleum Co., and by Cities Service Co. The bulk of America's formaldehyde is obtained by oxidation-dehydrogenation of methanol). According to Robeson,[6] hydrocarbon-derived formaldehyde contains small amounts of natural accelerator for the PE reaction. This is said to permit completion of the primary reaction period at 40-45 C in 30 minutes. The batch is then raised by 5-10 C to start the second reaction which completes the conversion to PE. The resulting product is low in polypentaerythritol.

There is no evidence that paraformaldehyde is today used to a significant extent in the production of PE, despite some evidence of useful—and possibly even improved yield.

Preliminary work by Wolfrom[7] indicated that paraformaldehyde leads to better PE yields than can be obtained from formaldehyde at like dilution. This finding is confirmed by Elderfield[8] who also points out a further practical advantage in the fact that the depolymerization of paraformaldehyde is accompanied by con-

siderable absorption of heat. This reduces materially the amount of cooling (or refrigeration) which is needed to control the PE reaction when monomeric formaldehyde is used.

The water content of formaldehyde is important since it, above all, determines the dilution of the reaction mixture. High formaldehyde concentration leads to excessive byproduct formation (notably dipentaerythritol) while very extensive dilution lowers reaction rate unduly and increases the cost of evaporating prior to PE crystallization. A commonly quoted range for formaldehyde concentration in the PE reaction is from 12 to 20 percent (considering the mixture formaldehyde-water only).

Attempts have been made to find workable conditions at higher formaldehyde concentration. Burghardt[9] claims good yield (up to 90 percent PE plus poly-PE) from 17-30 percent formaldehyde by using caustic soda as condensing agent and carefully controlling temperature below 30 C and acetaldehyde: formaldehyde ratio at approximately 1:4.5.

2. Acetaldehyde

Acetaldehyde is readily available as tech. (99 percent minimum) grade, in liquid form. The compound boils at 20.2 C and it is readily soluble in water. Mention has been made, in the literature, of techniques for introducing acetaldehyde vapor into the PE reactor. But for reasons of mechanical handling ease and of refrigeration economy, the use of liquid acetaldehyde is universally practiced in the manufacture of PE.

3. Condensing Agent

Practical and cost considerations confine the field of condensing agents to calcium hydroxide and sodium hydroxide. Common practice leans toward use of the former, mainly because it lends itself to simpler pH control and because of the ease with which it may be nearly quantitatively removed from the product.

There is little difference in the yield obtainable with these two condensing agents. In processes employing NaOH, particularly careful operating control must be exercised. Use of lower temperatures (even below 30 C) is not only possible but even essential, so that it is necessary to resort to mechanical refrigeration.

Gould[10] has developed a process in which formaldehyde remaining at the completion of the PE reaction is destroyed to improve the crystallization characteristics of PE and the phthalate color of the product. In this process, formaldehyde is converted by a Cannizzaro reaction with itself at 50-75 C in the presence of alkali. However, the presence of calcium ion is objectionable because it will promote the formation of formaldehyde polymers which add to phthalate color. In this process, it is therefore essential to remove calcium ion (by precipitation) and to replace the condensing agent with NaOH prior to the formaldehyde destruction step.

B. REACTION CONDITIONS

1. Method of Addition

Original production methods practiced the addition of a lime slurry to mixtures of the two reagent aldehydes. This order of addition was reversed when the importance of maintaining a dilute reaction system was realized. Simply by adding a mixture of the two aldehydes to lime, instead of retaining the reverse order of addition, Wolfrom[7] was able to raise PE yield by 10-14 percentage points.

Further benefits are derived by maintaining at all times a low concentration of acetaldehyde, so that self-condensation and Cannizzaro reactions of this highly reactive—and relatively costly—compound may be avoided. To attain this objective, acetaldehyde is added to an aqueous solution of formaldehyde in which lime has been suspended. (The extent of formaldehyde self-condensation is not too serious at initial low-temperature reaction conditions.)

This method of addition is probably the most attractive from the point of view of yield and product purity. In order to avoid local high concentrations of acetaldehyde, this compound is introduced into the well-agitated reaction system through a dip pipe.

The rate of acetaldehyde feed must be carefully controlled to avoid overheating due to the condensation reactions. Here, the determining factor is the available cooling capacity of the reaction equipment.

A variant method of addition[12] provides for simultaneous feeding of acetaldehyde and lime slurry—in separate streams—to the reactor containing formaldehyde solution. pH is carefully controlled. Good yield and ability to operate at high temperature (up to 85 C) are claimed for this approach.

2. Feed Ratios

Theoretically, four moles **formaldehyde** are required per mole acetaldehyde. Actually, by-products consume some of the formaldehyde so that a higher ratio must be used. A further controlling consideration is the fact that the PE-forming reaction drops off to negligible rate when formaldehyde concentration is below 0.8-1.0 percent. From practical considerations, the lower limit of the formaldehyde: acetaldehyde ratio is therefore set at 4.5.

The two factors governing maximum formaldehyde:acetaldehyde ratio are:

- Cost of the reagent and,
- The difficulty which is encountered in crystallizing specification-grade PE from a formaldehyde-rich crude liquor. To overcome the latter difficulty, various means are employed to destroy the residual formaldehyde. However, this means not only loss of this compound but also formation of objectionable secondary products (notably formic acid) and it is therefore necessary, even in processes of this type to hold formaldehyde:acetaldehyde moles ratio below 5.5.

The effect of aldehyde ratio on PE yield is demonstrated in the following data:[7]

Mole Ratio	Percent Yield, Crude Product
4.0	33.5
4.64	61.5
5.0	67.0
5.1	68.0
5.5	69.0

Except for mole ratio, conditions in the foregoing runs were held identical. By today's standards, Wolfrom's[7] yields (obtained in 1941) are low, but the data are nevertheless usefully indicative of the effect of the aldehyde feed ratio. Little is gained, yield-wise, by going to ratios above 5.0-5.1, and this is generally considered the optimum.

Mention might be made of Jackson's claim[11] that the use of very high feed ratios (up to 10) permit opera-

tion at low temperature throughout the batch time and thus minimize formation of byproducts, maximize yield of very pure (98-99 percent assay) PE. To handle the high aldehyde ratio, Jackson[11] distills off excess formaldehyde after the reaction liquor has been acidified in the customary manner (precipitation of calcium salt).

Theoretical *lime requirement* is one equivalent (0.5 moles) per 4 moles formaldehyde reacted to PE (lime is *consumed* only during the second stage, the Cannizzaro reaction). For adequate reaction rate and completion it is necessary to use excess alkali. Today's practice tends toward the use of 10-20 percent excess. Much larger amounts promote side reactions excessively at the finishing temperatures (30-42 C) in common use and cause difficulties in the separation steps, without offering adequate offsetting advantages.

3. Reaction time and temperature

These two variables are interdependent. The practical range is also affected by formaldehyde and alkali concentration. A wide range of temperatures (20 to 85 C) and reaction times (1½ hours to several weeks) is mentioned in the literature. Obviously, increasing the temperature reduces batch time but it is also accompanied by side reactions to an increasing extent—side reactions which may be only partly offet by adjustment of other variables.

30-45 C. is usually mentioned as the feasible maximum in commercial practice, with a finishing temperature (after the "second reaction") as high as 55 C. Recent work by Peters and Quinn[13] indicates that these temperatures—if held uniformly through the batch—may be too low to permit satisfactory yield within a reasonable time.

Using NaOH as condensing agent, these authors report the following temperature-yield relationship after 95 minutes batch time.

Reaction Temperature, C	Over-all PE Yield, Percent
35	47
50	52
61	58
70	70
84	77

By increasing reaction time at 60 C to 330 minutes, yield could be boosted only to 64 percent.

These results are at variance with other available data. Peters and Quinn believe that the good yields obtained by other investigators at low batch temperatures is due to local hotspots which may arise from the exothermic reaction in a poorly agitated system. An alternate explanation may be that 95 minutes, the time allowed by Peters and Quinn, is not sufficient to permit the "second reaction" to take place. The importance of this phase on PE yield will be considered below in the "Second Reaction."

FIGURE 4—Control panel of a pentaerythritol plant. Reactor is seen in the background.

Most investigators have made a special effort to keep the temperature below 30 C during the addition. Following addition, temperature is boosted, permitting a maximum as high as 50 C. after the onset of the "second reaction." Batch time (including addition) is variously reported at 1½ to 5 hours. Illustrative are conditions at one commercial plant where addition is made at 18 C. (i.e., just below the boiling point of acetaldehyde). After about two hours the system temperature is raised to 60 C. to complete conversion and remove formaldehyde.[23]

In order that completeness of the desired reaction may be assured, after the ingredients have been fully introduced, it is customary to permit the temperature to rise to a point just below the point at which a dark yellow or brown color develops. Here, the batch is held until the falling aldehyde concentration of the solution shows no further tendency to diminish (see "second reaction").

According to Wolfrom,[7] the reaction proper is complete in 20 minutes at 55-60 C, and the rate of addition of aldehydes—at a given temperature—does not affect the yield of product. However, if the reaction is stopped at the end of 20 minutes by precipitating the calcium with an acid (such an oxalic), condensation leads to a syrupy solution from which the PE crystallizes only with diffi-

culty. No such difficulty was noted when the Na_2CO_3 served to precipitate calcium, since then the medium remains alkaline, suitable for destruction of residual formaldehyde by Cannizzaro reaction.

4. pH Control

Careful control of pH has important effect on yield and, especially, purity of product. The optimum range during the reaction period is 9.0-9.5. This may be maintained by adding the lime slurry in a parallel stream with the acetaldehyde feed to the reactor, and controlling the rate of condensing agent addition by the observed pH.[12]

For reasons outlined above, it is more common to introduce the entire lime slurry with the formalin. A refinement in carrying out the reaction is to effect part-acidification to pH of 9.0 after all the acetaldehyde has been introduced, but before completion of the reaction period. Such adjustment, which can be accomplished by means of formic acid, acetic acid, or another acid with which calcium forms water-soluble salts, reduces the tendency of residual formaldehyde to enter into self-condensation and polymerization reactions.

5. Final Formaldehyde Concentration

It is necessary that formaldehyde concentration at the end of the PE reaction be at least 0.8-1.0 percent. At lower concentrations, the reaction rate is slowed down below the point where it can be practicably completed.

The concentration of residual formaldehyde is determined above all, by the aldehyde feed ratio, which has already been discussed, as well as by the degree of dilution. Methods for eliminating excess formaldehyde, where such action is needed, will be considered later in "Finishing Conditions."

6. The "Second Reaction"

As previously mentioned, a second reaction occurs spontaneously some time after all the acetaldehyde has been fed to the system. This reaction is observed by a sudden rise in temperature and some yellowing of the solution. Regarding this second reaction, Elderfield[8] writes as follows:

> "It appears to be quite definitely established that unless the second reaction takes place, the quality of the PE suffers very greatly and the yield decreases. While the chemistry involved in the second reaction is obscure, the fact remains that in no case where the second reaction was not allowed to take place, was a satisfactory product obtained . . .
>
> "The time elapsed after the onset of the second reaction until working up appears to be relatively unimportant. The reaction is characterized by a sudden rise in temperature followed shortly by the development of a yellow color in the reaction mixture. It makes little difference whether the reaction is worked up a few minutes later or as much as two hours later."

7. Special Aids for the Cannizzaro Reaction

Equation (1) shows that the synthesis of PE consists of two successive reactions, both of which are catalyzed by alkali. The second of these stages, the Cannizzaro reaction, is the more time-consuming of the two. Its purpose is to reduce pentaerythrose. In its execution, formaldehyde is consumed, and formates are produced. There is some evidence that the presence of these formates has a deleterious effect on ease of PE crystallization.

Means have been sought (a) to accelerate and direct the Cannizzaro reaction, and (b) to use an alternate reaction which might result in lowered formaldehyde consumption.

In the first category is a process by Cox[14] in which a catalyst, notably Raney nickel or a copper salt is added to the reaction batch some time after all the ingredients have been introduced, and just before the solution turns syrupy. Similarly, Issoire[24] catalyzed the PE reaction with copper oxalate at the outset and with cuprous oxide during the finishing (high-temperature) stage. This technique gave a yield of 85-90 percent at conditions which yielded only 60-70 percent PE in the absence of copper salts.

Use of hydrogen to convert at least part of pentaerythrose to PE has been patented by Walker.[15] The conversion is carried out on crude reaction liquor obtained from low formaldehyde: acetaldehyde feed ratio (say, 3.8). Hydrogen Pressure is 1500-2000 pounds per square inch. Operation is at room temperature in the presence of Raney nickel. The product is worked up in the usual manner.

Yield of 89 percent is claimed, compared to 71.5 percent (on acetaldehyde) in a parallel run without hydrogenation (but note the use of a low aldehyde ratio).

C. RECOVERY STAGE

The customary method for working up the reaction mixture involves precipitation of the calcium ions followed by filtration. The filtrate is concentrated by vacuum evaporation and PE is recovered from the concentrate by crystallization.

Difficulties may occur in the crystallization step due to the formation of a syrupy liquor. This trouble has been traced to the presence of a number of impurities. The following sections deal with means which have been developed to overcome recovery and purification difficulties and to provide maximum yield.

1. Elimination of Residual Calcium

Calcium is present in the crude liquor by virtue of the use of lime as condensing agent. It is necessary to remove this material which would contribute to the ash content of the product.

One approach is the neutralization or acidification of the mix with formic acid which will yield water-soluble calcium formate, separable, by virtue of its solubility, from crystallized PE. This method, however, leads to build-up of calcium in the mother liquor and is not fully satisfactory from a yield-point of view because it introduces objectionable formic acid (see below) and calls for extensive washing of the product.

The commercial approach involves precipitation of the calcium ion. This may be accomplished by acidification with sulfuric acid, sometimes followed by a cleanup with oxalic acid. There are, however, advantages to retaining the medium on the alkaline side (pH of 9.0 to 9.5) as will be seen in the next section. This purpose is served, and precipitation of calcium is accomplished at the same time, by treating the crude liquor with sodium carbonate.

The precipitate, be it calcium sulfate, calcium oxalate, or calcium carbonate is removed from the process liquor by centrifugation.

2. Nature of Impurities and their Removal

Three groups of compounds are blamed for most of the difficulties encountered in PE recovery: formaldehyde, formic acid and its salts, and

miscellaneous organic compounds, notably polyhydroxy compounds and acetals (including dipentaerythritol, formose, aldol, etc.).

Unconverted **formaldehyde** is of course, always present at the end of the reaction. As we have seen its concentration in the crude liquor is about one percent.

It is observed that the presence of formaldehyde lowers the yield of PE in the crystallization stage. For this reason, residual concentration of the aldehyde should be as low as possible certainly less than 0.6 percent.

If the solution is kept slightly alkaline, such reduction occurs in the course of evaporation which takes the solution to formaldehyde-destroying temperatures. The principal reactions occurring at such conditions are Cannizzaro reaction and polymerizations. According to Gould,[10] reactions of the latter type are objectionable because they contribute to high phthalate color of the product, while no such drawback attaches to Cannizzaro conversion of formaldehyde.

Gould states that the undesirable polymerization reaction takes place preferentially in the presence of calcium ion, but that caustic soda, at a pH of about 9.0 and in the absence of calcium ion, destroys formaldehyde without deleterious effect on the phthalate color of product PE. For this purpose, he precipitates calcium salt and then treats the filtered solution with sodium hydroxide.

This finding parallels Wolfrom's observation[7] that good crystallization of PE is attained if calcium is precipitated by sodium carbonate. Such a step will, of course, remove insoluble calcium carbonate, and leave sodium hydroxide in solution.

In acid medium (e.g., if calcium is precipitated by sulfuric acid and there is no subsequent adjustment of pH), there is no significant destruction of residual formaldehyde at evaporator temperature.

A distillative method[11] for removal of large amounts of residual formaldehyde has already been mentioned.

Formic acid is formed in the course of PE reactions, as well as in the Cannizzaro reaction of formaldehyde referred to in the preceding paragraphs. This acid, or more specifically, its high-boiling esters which are formed in the batch, has also been blamed for the syrupy formations which impede PE crystallization. Cox[16] proposes to overcome this difficulty by reacting combined formic acid with methanol or ethanol, after the calcium has been precipitated. A ternary azeotrope of water, alcohol, and formic acid ester can be distilled off, leaving a liquor which will reportedly provide improved PE yield.

Wyler[17] proposes to extract both formic acid and by-product polyhydroxy compounds, using tributyl phosphate as solvent.

Also for the purpose of removing formic acid, Cox[18] recommends extraction of the calcium-free crude liquor by means of ethyl acetate. He reports 80 percent PE yield (based on acetaldehyde).

Miscellaneous organic by-products are held responsible for high color in the product as well as for difficulties in crystallization. To destroy these objectionable materials—or their parent compounds—Wyler[17] recommends that the liquor be treated with hydrogen peroxide prior to evaporation.

Mertz[20] recovers PE and organic syrups, free of metal formates, from waste mother liquor by spray drying the liquor, extracting the solids with tert-butyl alcohol, filtering, and evaporating the filtrate to dryness.

3. Finishing Conditions

It has been shown above that it is beneficial to remove excess formaldehyde prior to concentrating and crystallizing the PE. As we have noted, this can be accomplished by heating the solution in alkaline medium, preferably sodium hydroxide solution at a pH of 9.0—9.5.

Following destruction of formaldehyde, it is useful to improve crystallization conditions by lowering the pH of the liquor to 7.0—8.0 prior to evaporation. Even lower pH is acceptable. Especially where calcium is precipitated by means of sulfuric acid and formaldehyde destruction is not practiced, the residual pH may be as low as 3.0-4.0.

Typically, this solution, when combined with filter wash waters, will contain about 7 weight percent PE. This solution is now evaporated under vacuum (26-28 in. Hg), to about one-quarter of its original. It is then slowly cooled to 10 C. The resulting PE crystals are separated by filtration or centrifugation and are washed with ice-water.

The filtrate liquor may be further concentrated to about one-half volume and a second PE crystal crop may be obtained at 10 C. Yield at this point is of the order of 70-75 percent (overall referred to acetaldehyde). If process conditions have been maintained which lead to minimum by-product formation, it is possible to recover a third crop of PE crystals to raise the overall yield to some 80 percent of theory.

Commercial PE Specifications

There are two major grades of pentaerythritol on the market—technical and mono—PE.

Technical PE constitutes by far the bulk of the output. The following sales specifications, set by one manufacturer,[21] are typical of technical PE.

Color and Appearance	White, free-flowing powder	
Mono-Pentaerythritol Content (dibenzal method)	**Maximum** 88.0%	**Minimum** 85.0%
Hydroxyl Content	47.0	46.0
Ash (as sulfate)	0.2	
Moisture	0.5	
APHA Color—10 percent water solution	50 Hazen	
Water Solubility (10 percent solution)	Clear for 24 Hours at 25 C.	
Particle Size	⅛ inch	

The same manufacturer[22] reports the following analysis as typical of his mono—PE:

Mono—PE (dibenzal method)	99 percent
Hydroxyl (OH)	49.5 percent
Ash	Nil
Total Solids	99.6 percent
Melting Range (Capillary)	250-258 C

Both grades are available as "dust-free" product. Pentaerythritol is normally shipped in 50-pound bags.

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Are Explosion-Proof Motors Necessary?

Here is a way to design new units and change existing areas so the need for explosion-proof motors is eliminated.

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FOR MANY YEARS it has been the generally accepted practice in petroleum refinery electrical design to use explosion-proof equipment wherever such equipment was available. As applied to squirrel cage induction motors, this conservative attitude had a twofold purpose: First, the prevention of ignition of possible explosive atmospheres surrounding the motor, and second, the protection of the motor internals from the effects of the weather, since a large percentage of the motors were installed outdoors.

With rapidly increasing electrification of refinery operations, it becomes apparent that a reclassification of certain areas might offer considerable savings without sacrifice in safety or effectiveness of equipment operation.

Studies and tests of specific refinery areas indicate that atmospheres in the Baton Rouge Refinery of Esso Standard Oil Company which must be classified as National Electrical Code Class I, Group D, Division 1 are few in number and limited in scope. The recent release of API Recommended Practice 500 has served to bolster our belief that squirrel cage induction motors may be used in most refinery atmospheres without the requirement of an explosion-proof enclosure. With regard to protection from the weather, recent developments in motor winding insulation and motor enclosures appear to offer considerable savings through use of less costly enclosures for motors to be used outdoors.

In the selection of industrial equipment, economics dictate installation of the least expensive unit which is suitable for the job. In the case of electric motors, consideration must be given to safety, reliability, maintenance, and life span, as well as first cost. Over the past ten years, savings have been taken advantage of as various refinery areas were reclassified. Present practices in use of nonexplosion-proof motors have developed gradually over the past several years.

Weather-Protected Motors in Refinery Tank Fields—About ten years ago explosion-proof motors were used almost exclusively in refinery operating areas. Considerable savings could be made in motor costs through a reclassification of certain areas. About this time it was planned to install several large motors sizes 500 and 600 hp in some tank fields. After examination of the areas involved it was decided that tank field areas outside firewalls were nonhazardous and beyond the scope of National Electrical Code Article 500. The most economical enclosure then available which appeared to be suitable was the splashproof type. Several of these were installed in 1947 and 1948. Our experience with splashproof motors for outdoor use proved unsatisfactory. All of these motors failed from water being drawn inside the enclosure with the ventilating air during rainstorms. In order to continue using these motors it became necessary to provide a housing over each one to protect it from the weather.

Because of this trouble, explosion-proof motors were used for all outdoor applications until 1951, at which time interest was aroused in the newly developed weather-protected motor. The design of this motor appeared to be the solution to the problem. At that time this weather-protected type motor was relatively new and little was known about its ability to withstand long term exposure to damp and corrosive air. These motors had been subjected to a variety of spectacular tests; i.e., subjecting them to man-made hurricanes, squirting them with high pressure fire hoses, and directing the spray from fog nozzles into the air intakes. Their ability to undergo such tests without getting water into the stator windings and their lower cost as compared to an equivalent explosion-proof motor made them appear very attractive for outdoor use.

In 1952, the first weather-protected motor was installed in the refinery. Motors of this type have been used in both general purpose and Division 2 areas. Since 1952, 25 weather-protected motors ranging in size from 200 to 900 hp have been installed. They are all 2300 volt, three phase, squirrel cage induction motors operating at speeds from 900 to 3600 revolutions per minute. These motors are of both vertical and horizontal types and all drive centrifugal pumps. Some operate continuously and some are in intermittent service. All are located outdoors where they are subject to dust, rain, fog, and other weather conditions. Performance has been pleasing. In the past four years there has been no trouble with motor

STEPS IN CHANGING TO NON EXPLOSION-PROOF MOTORS

- **The use of weather-protected motors in sizes from 200 to 900 horsepower in open areas of refinery tank fields.**
- **The use of modified drip-proof enclosures for motors 1000 hp and above, usually located in freely ventilated refinery compressor houses.**
- **The use of totally enclosed fan cooled motors throughout the refinery in lieu of explosion-proof motors in sizes below 200 hp.**
- **The use of weather-protected motors in sizes from 200 to 900 hp in process unit areas as well as in refinery tank fields.**
- **The possible future use of drip-proof motors in outdoor service, by application of some of the recently developed moisture resisting insulations.**

winding insulation or other parts that might be subjected to more severe service conditions with a weather-protected enclosure than with an explosion-proof enclosure.

Considerable savings are made through the use of weather-protected motors in place of totally enclosed fan cooled (TEFC) and explosion-proof motors. TEFC motors are 30 to 60 percent more costly initially than equivalent weather-protected motors in sizes from 200 to 900 hp, depending upon size and speed. Explosion-proof motors are 40 to 70 percent more costly in the same sizes.

Large Motors—Increasing use has been made in the last few years of motors sized 1000 hp and up as drivers for large centrifugal blowers and compressors. One 1750 hp and two 4000 hp motors were purchased in 1953 for use in Class I, Group D, Division 1 areas. These were totally enclosed, inert gas pressurized (TEIGP), water cooled motors for installation in compressor houses. Unusual problems were involved in making motor installations of this type, such as selecting a suitable pressurizing medium and providing an adequate water supply for cooling. It is desirable to avoid using this type motor if at all possible since it has a number of disadvantages.

The initial motor cost and installation cost are higher than that of other motors. It is subject to emergency shutdowns from water cooler leaks and fouling of cooler tubes. During an inspection of the 1750 hp motor, its cooler was found to be fouled with wood chips from the cooling tower which served it. A 3000 hp motor of this design failed as the result of a leak in one of the cooler tubes spraying water into the windings. A number of control devices are necessary for the regulation of pressurizing gas and cooling water, each of which is a potential source of trouble. Because of the additional equipment involved, maintenance is generally higher than that for other types of motors.

It is felt that the need for a motor of this type can be avoided by designing compressor houses so they can be classified Class I, Group D, Division 2 rather than Division 1. Compressor houses built in recent years are of steel and transite construction, open on all four sides from grade up to about eight feet above the floors. Most floors are elevated several feet above grade and are made of subway grating. Good ventilation is obtained by the free passage of air through the building which disperses any small amounts of hydrocarbon vapors that may be present from small leaks around packing glands, etc. The houses in which the three motors above are installed are of this type, and were reclassified as Division 2 locations in 1954.

In February, 1956, the 1750 hp motor was converted from TEIGP to open type self-ventilated. The necessary parts were obtained from the motor manufacturer and the actual work was done by refinery people. Necessary parts have been obtained for

the conversion of one of the 4000 hp, 13,000 volt TEIGP motors. This work will also be done by refinery forces. The other 4000 hp motor will be converted when the unit that it is associated with comes down for a turnaround early in 1957.

There are eight large induction motors in the refinery ranging in size from 1000 to 4000 hp. Two of these are fourteen-year-old explosion-proof motors located outdoors. The other motors are located inside compressor houses classified Class I, Group D, Division 2 and are either of the drip-proof type or are being modified as described above. For all new large motors to be located indoors in Division 2 and general purpose areas, drip-proof enclosures are specified.

It is a common practice in the refinery to wash down compressor house floors with high pressure water hoses. In order to protect both personnel and equipment we feel that additional baffles or some other form of protection is necessary to prevent a water stream from being directed into the motor windings. To accomplish this it was specified that the motor enclosure shall be constructed to prevent water from striking the windings directly if a hose is accidentally directed on the motor during hosing down operations.

Two motors of this type were installed recently—a 1250 hp motor to drive an air blower and a 1750 hp motor to drive a centrifugal gas compressor. The 1250 hp motor is a boiler feed pump type motor with air intake on both sides and discharge outlet at the top on the drive shaft end over the end shield. Baffles are arranged inside the intake openings to protect against water being directed into the windings. The discharge opening is high enough above the floor that the possibility of water splashing that high is unlikely. The 1750 hp motor has air intakes on both sides and air discharge through the bottom. Additional baffles were included at no extra cost to provide protection against hosing.

Motors Below 200 Horsepower—As the above applications of nonexplosion-proof motors in Division 2 locations developed, the use of explosion-proof motors below 200 hp was continued. The basis for this was the fact that a totally enclosed fan cooled motor was required in these sizes to get proper weather protection for outdoor service. Since the percentage savings which could be realized was small, it was felt that we should continue the use of explosion-proof motors in these sizes to allow complete interchangeability of smaller motors between areas of different classifications. It is now felt, however, that the requirement for an explosion-proof motor is the exception rather than the rule in refinery applications, and although the percentage savings are small, considerable overall savings can be made by using TEFC motors throughout. Application of explosion-proof motors will be limited to locations classified as Class I, Group D, Division 1. Designing has been done on this basis for about one year.

Weather-Protected Motors in Process Unit Areas—About the same time TEFC motors were put into use, weather-protected motors were adopted for larger installations on process units in areas classified as Division 2. At present engineering is in progress for the construction of a new process unit for which both weather-protected and TEFC motors have been purchased to drive the on-site process pumps. The savings realized on this unit alone through use of nonexplosion-proof motors amount to $15,000.

Use of Open Motors Outdoors—According to motor manufacturers the new types of insulating materials available today for motor windings give longer motor life by providing added protection against moisture, foreign particles, corrosive atmospheres and the like.

A 600 hp drip-proof motor was recently purchased to be installed outdoors. It has Class B silicone elastomer insulation and is a 60 C. rise motor. The manufacturer claims this motor is suitable for use outdoors and provides the same warranty as with a weather-protected motor. The requirement for this particular application was approximately 650 hp. Had a weather-protected motor been used it would have required a 700 hp motor since its service factor is 1.00. By using the drip-proof motor we were able to use a 600 hp motor as it has a service factor of 1.15. A weather-protected motor of the same size, made by the same manufacturer, would have cost 31 percent more than the drip-proof motor. A 700 hp weather-protected motor made by this manufacturer would have cost 48 percent more. If this type motor proves satisfactory for outdoor service, it appears that considerable further savings may be realized through the use of specially insulated drip-proof rather than weather-protected motors. At least one other motor manufacturer offers a motor of the drip-proof type with a special Class A insulation recommended for use outdoors.

Savings To Be Realized—The savings which may be realized through use of the above precepts are considerable. For example, the 25 weather-protected motors we now have in service cost almost $100,000 less than equivalent motors in explosion-proof enclosures.

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Meet the Author

ENOCH TALLEY has been with the Esso Standard Oil Company's Baton Rouge refinery for five years. There he is a member of the mechanical engineering department, responsible for engineering design and coodination of new electrical construction projects associated with the refinery's high voltage electrical distribution system. He is a graduate of the Louisiana State University, obtaining the B.S. degree in electrical engineering from its College of Engineering in 1949. For two years following graduation, he was an engineer with the Southern Bell Telephone & Telegraph Company. He joined the Esso Company early in 1952.

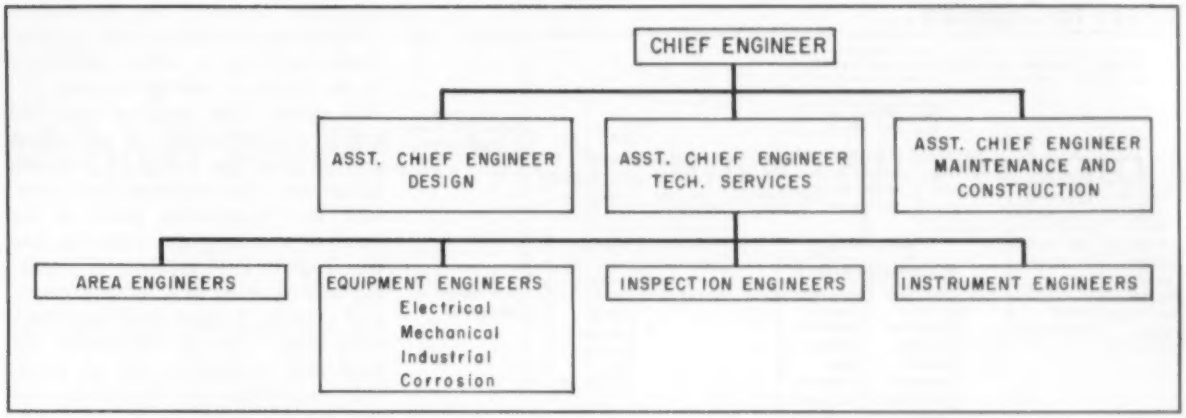

FIGURE 1—Refinery engineering department organization.

It Pays to Organize

Corrosion costs can be cut quicker by unified group action. A company wide corrosion organization can multiply the efforts of each corrosion engineer.

Gayden Derickson
Shell Oil Company
New York City

DURING THE past ten years the Shell Oil Company has developed an organization which integrates its refinery corrosion engineering with other branches of the company to unify and coordinate work on corrosion problems. Factors which influenced the company-wide organization included: the selection of the refinery corrosion engineer, his environment and equipment and the refinery organization.

The essential requirement for a successful process corrosion engineer is the complete understanding on his part of the physics and chemistry of corrosion itself. He should be able to initiate analytical laboratory work on the products of corrosion and if necessary outline a research program if the factors producing corrosion are obscure. He must have an intimate knowledge of refinery process operations and at the same time be familiar with engineering materials and their working characteristics. Experience indicates the process corrosion engineer should be a professional man having at least five years refinery background. The ultimate, in our opinion, is the chemical engineer who has a pronounced interest in metallurgy, or conversely the metallurgical engineer who has a strong inclination toward process chemistry. However, successful, qualified, process corrosion engineers have come from other branches of the profession.

He should have the ability to perform economic evaluations, write effective reports, and have the initiative to seek out his problems instead of waiting for them to come to him. It is unlikely that a man having all these attributes can be found but the more nearly he fits this description the more effective the corrosion program will be.

In addition to the process corrosion there are two other rather clear cut fields of corrosion abatement each having its engineers. They are atmospheric corrosion engineers and cathodic protection engineers. Both of these should have the same general attributes as the process corrosion engineer but their technical training requirements differ.

The atmospheric corrosion engineer, or paint engineer is concerned with external protective coatings and their application. Here again a chemical engineer who has developed some proficiency in industrial engineering or more specifically materials handling makes the ideal man.

The cathodic protection, or soil corrosion engineer is usually an electrical engineer. Frequently, his soil corrosion work is combined with other electrical engineering duties. The need for the cathodic protection engineer is greatest in older large refineries where the piping is underground. A new modern refinery with above grade pipe racks or alleys has little need for this specialist.

Environment and Equipment—All too frequently the right man is selected and then not placed in the proper environment or provided with adequate facilities. Our company has made a point of locating the corrosion engineer in that division of the engineering department which is in close contact with refinery operations, maintenance, inspection and design. He is given ready access to the refinery analytical laboratory and a mechanical materials testing laboratory. Without going into detailed description of equipment the corrosion engineer has available among other equipment a: tensiometer, an impact tester, a metallographic microscope, hardness testers, a small heat treating furnace, temperature measuring equipment, and electrolytic corrosion measurement equipment such as the: potentiometer-volt meter, copper sulfate electrodes, resistance probe, resistance meter, pH indicator set, and coating thickness tester.

Adequate equipment has proved to be a worthwhile investment.

Refinery Organization—Figure 1 shows in simplified form the refinery

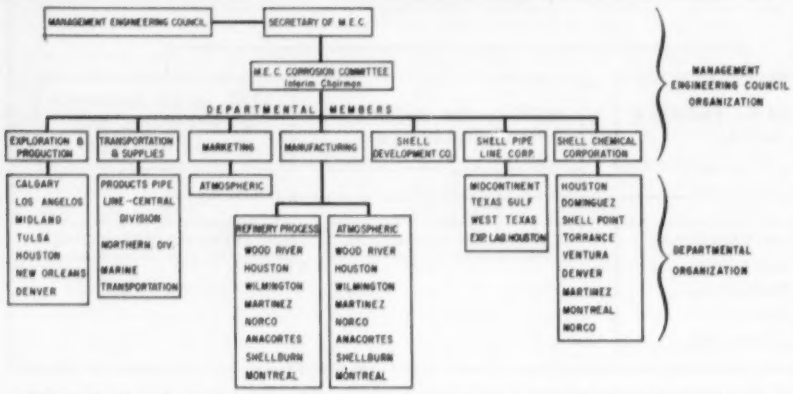

FIGURE 2—Organization chart of the management engineering council corrosion committee.

engineering department which, under the chief engineer, is divided into three basic divisions of equal stature. These are:

- Maintenance and Construction
- Design
- Technical Services

The subdivisions under the Design, and Maintenance and Construction sections have been omitted and attention is focussed on Technical services. The corrosion engineers are shown in the group of equipment specialists under the assistant chief engineer. As the name implies, the Technical Services Division was established to provide in-the-plant engineering personnel to handle, as rapidly as possible, the many problems that arise daily in process unit operation and maintenance. These may be problems of corrosion, heat transfer, mechanical efficiency, materials handling, or many others for which a design section is usually not geared for immediate handling due to the press of approved major design projects. It is apparent that we have placed the corrosion engineer in close relationship to those engineers who in turn are closest in their daily work to process operations.

It is recognized that many companies do their corrosion work within their inspection departments. However, there is a word of caution to be said against this as there is a tendency to let the corrosion engineer become involved in too many matters of a routine inspection nature.

Company-Wide Organization—There should be no doubt that the responsibility for the successful solution to corrosion problems rest on the individual corrosion engineer. However, the over-all organization through which he works is of great importance in providing him with a means for the inter-change of information with other corrosion groups outside of the refinery and a means of obtaining company-wide cooperation on major corrosion problems.

Figure 2 develops the organization on a company-wide basis. It is completely decentralized to keep the responsibility at the refinery level where it belongs and it is not concerned with routine corrosion problems of a local type. In the manufacturing department there are two standing committees, the Refinery Process Corrosion Committee and the Atmospheric Corrosion Committee. Both of these committees are composed of a member from each refinery. Through their respective chairmen, all activities are reported to the Head Office Manufacturing Department representative. He, in turn, is a member of our Management Engineering Council Corrosion Committee which is made up of one counterpart member from each division of the company and our associated companies. This senior group furnishes the means for cutting across departmental lines and provides a ready contact on mutual problems. The chairman of this group reports all corrosion activity to the Management Engineering Council through the permanent secretary. By definition, the Management Engineering Council is a senior group at management level which reviews and reports on engineering developments of value to at least two or more major divisions of Shell Oil Company.

The way in which the organization operates can best be illustrated by examples. Consider the well-known problem of hydrogen attack on steel which has been so widely publicized in the literature during the past several years. This problem was one which affected safety of operations and, in fact, the ability to continue in operation the important high pressure, low temperature plants in the catalytic cracking gas recovery system. Late in 1948 evidence of blistering was reported to a refinery corrosion engineer by the plant inspection department. Shortly thereafter the local staff recognized that all available experience and knowledge on the subject must be brought into action as soon as possible. Through the Management Engineering Council Committee, a research program was initiated at the development company; and a team composed of the refinery corrosion engineer, the manufacturing department corrosion committee chairman and a research representative made an exhaustive study of all information that could be obtained throughout the oil and other industries. At the same time an intensive experimental program was set up at the refinery.

The Atmospheric Corrosion Committee provides another illustration of the value of the organization. Following World War II, one refinery of our group was particularly dissatisfied with the cost and service life they were getting from their paint work. An aggressive corrosion engineer working through his atmospheric committee was able to obtain the experience and recommendations of many independent laboratories, consultants and contractors. On the basis of such information plus his own tests and ideas he drastically revised material specifications, surface preparation and application methods. With management backing he in effect turned this refinery into a large scale coatings proving ground. The results of this local program were highly successful and the committee again became active in making detailed reports on the program available to all other company locations. The net result is that the company is now benefiting by a 40 percent reduction in direct painting costs and coating service life is now three to five times that of pre-war experience.

Originally presented at the API meeting, Montreal, Canada, May 15, 1956. ##

Which Steel for High Temperature Piping

Here is a look at the most commonly used piping materials for modern high temperature refinery service.

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Chicago

MATERIALS FOR high temperature service are selected primarily on the basis of their strength (short-time, creep and rupture) although it should be evident that other characteristics such as ductility, corrosion and erosion resistance, structural stability, weldability, and so on must be adequate. It is fortunate indeed that many of these requirements are fulfilled in an economical manner by one basic material, namely, carbon steel. We are prone to overlook the versatility of carbon steel as offered by variations in method of manufacture, composition and heat treatment. So adaptable is this simple iron-carbon alloy that in some instances it is employed for temperatures up to 1100 F. though admittedly at low pressure and in reducing atmosphere.

Where greater fluid pressure must be contained in this temperature range, a higher strength material is available in the form of carbon-molybdenum steel. This low alloy steel has essentially the same desirable characteristics as carbon steel in addition to the improved high temperature strength. Its field of greatest application is in the temperature range from 700 to 1100 F.

Processing conditions often require greater high temperature corrosion resistance than is obtained with the two aforementioned steels and, to meet this need, a wide variety of chromium-molybdenum alloy steels is available. Use of these materials may start at about 800 F. and extend to 1100 F. in the case of ½ percent and one percent chromium steels (with ½ percent molybdenum) or to about 1300 F. with 9 percent Cr: 1 percent Mo steel. Included in this general category is the well known 5 percent Cr: ½ percent Mo steel which has served the industry so admirably for approximately thirty years.

In some cases straight chromium steels of greater alloy content have been employed to cope with particularly corrosive fluids. These materials with chromium levels of about 12, 17 and 27 percent are not ordinarily used for high pressure applications above 1000 F. due to lack of strength but may be utilized for even higher temperatures because of their superior oxidation resistance. The 12 and 17 percent chromium steels, falling within the stainless steel classification, have been used extensively for valve trim.

For extreme pressure conditions, occasionally to temperatures as high as 1500 F., engineers have often resorted to use of the austenitic chromium-nickel steels because of their high creep and rupture resistance. These steels contain 18 percent or more chromium with 8 percent or more nickel and may be modified by additions of other elements to confer special characteristics. In view of the excellent high temperature corrosion resistance of the austenitic steels and of the straight chromium steels, it is not surprising that these alloys are sometimes used as lining materials for less costly steels.

Temperature ranges designated for the various steels are subject to modification as conditions and judgement may warrant. The materials listed above are not, of course, the only ones applied in high temperature refinery operations but are believed to be the more important alloys in use today. Attention will now be directed to some of the more recent developments in connection with the use of these steels.

Graphitization—In 1943 a welded carbon-molybdenum steel main steam line fractured next to a weld. This

Meet the Author

ERNEST A. STICHA attended Lewis Institute (now Illinois Institute of Technology) and received his B.S. degree in electrical engineering in 1933. He then did graduate work at University of Michigan, and in 1936 received a Masters degree in metallurgical engineering. Since that time he has been employed by Crane Company, first in the metallurgical department, and later in the engineering laboratories. Sticha is now supervising engineer of the metals testing laboratory where he is closely associated with studies involving applications of metals, particularly in the high temperature field. He is currently Chairman of the Pipe Fabrication Institute Metallurgical Committee.

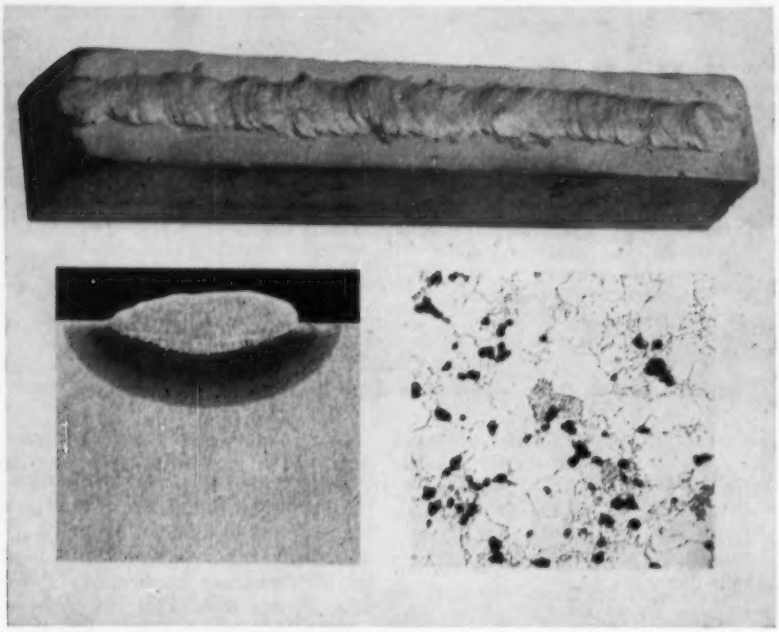

FIGURE 1—Test shows graphitization phenomenon. A weld bead specimen (top figure) of this type produces a cross-section (lower left) like this which shows graphite development (lower right) after aging.

line had been in service carrying 925 F. steam for about five years and examination showed that structural breakdown of the carbide phase in the steel resulting in segregated graphite formation at the edge of the weld-heat-affected zone led to the failure. While this incident caused great concern among steam power engineers, the petroleum industry with similar material operating under comparable temperature conditions seemed little perturbed. However, several years later when investigation of a cracked reactor revealed random graphitization, an extensive survey of high temperature equipment was undertaken, results of which have been reported recently by Wilson.[1]

Both carbon and carbon-molybdenum steels were found to be susceptible to development of graphite which occurred usually in a random pattern throughout the steel but sometimes as a heavily segregated formation paralleling the weld fusion line. One of the prime variables responsible for the carbide instability was reported to be steel-making practice and, in this connection, a large aluminum addition for deoxidation was found to promote graphitization. It was also noted that higher operating temperatures favored graphite formation. A few instances of seemingly anomalous behavior were observed. This experience is essentially the same as that which came out of a study of steam power piping materials.

Considerable laboratory effort has been expended in studying the graphitization phenomenon. In general, this work has followed along three channels, namely, evaluation of variations in melting practice, heat treatment and composition. The first two approaches have not been particularly fruitful in suggesting practical means of combatting graphite formation in service and the third, the use of alloying elements, has been generally adopted by industry. The usual procedure in laboratory studies is to deposit a weld bead along a chilled bar of steel, expose the sample at a temperature known to accelerate development of graphite, and then examine the structure periodically under a microscope (Figure 1). Miniature bend and/or tensile tests may be conducted to assist in the evaluation of materials. Results of these tests are in good agreement with service experience except that the laboratory tests rarely, if ever, develop an intergranular graphite segregation. A summary of some of the work undertaken is shown in Figure 2. Here the degree of conversion of carbide to graphite has been estimated after various exposure times.

Within the scope of this investigation, it is immediately apparent that there is relatively little difference in the behavior of steels made by various melting processes except in the case of bessemer steel. This material exhibits unusually good resistance to graphitization but unfortunately suffers from certain other defects which render it unsuitable for use in critical piping installations. The effect of aluminum additions is also quite pronounced. One might infer from these test results that absence of aluminum will guarantee immunity from graphite formation but even those steels which are deoxidized with silicon only develop graphite after more prolonged aging. Post-weld heat treatment is shown to exert a minor influence on graphitization susceptibility. Some treatments have been shown to retard graphite formation but no practical procedure eliminates it.

The role of several alloying elements in carbon-molybdenum steel is shown in Figure 2 also. Increasing molybdenum content from the nominal ½ percent level to 1 percent imparts little added resistance to graphitization. The same applies to addition of nickel to the extent of 1¼ percent and, though not shown, vanadium is of little help in combatting graphitization. Only chromium and manganese of the more common alloying elements are effective in retarding graphite formation and, of these, chromium is the better. Thus it is that chromium-molybdenum steels are now being specified for high temperature piping where previously carbon-molybdenum steel was employed. On the basis of equipment surveys and laboratory tests, it is general practice to restrict welded carbon steel piping to a maximum of 750 F. and carbon-molybdenum steel to 850 F. Another consequence of the graphitization problem with these steels and the resultant limited range of application of carbon-molybdenum steel is the apparent elimination of cast valves of this material as a regular stock item.

The effect of residual amounts of certain elements in steel may account for the anomalous behavior of some samples with respect to graphitizing tendency. However, it seems more

than likely that elements which are not usually determined analytically may be responsible for this condition. The remarkable resistance to graphitization of bessemer steel also suggests this possibility and nitrogen, which runs much higher in bessemer than in other steels, has been shown by several investigators[2, 3] to inhibit graphite formation. The possible influence of nitrogen may be modified by the presence of strong nitride-formers like aluminum, chromium, etc.

Limitation of Carbon Steels—It is sometimes a source of confusion to engineers why certain carbon steels are assigned allowable stress values in codes to 1100 F. (e.g. ASTM A 106 pipe) while others are restricted to only 400 F. (e.g. ASTM A 53 bessemer pipe). This situation reflects, to a great extent, differences which result from steel-making practices. Such characteristics are not revealed by room temperature tensile tests but may be indicated by a maximum in the curve of tensile strength versus temperature, usually in the region of 400 to 500 F. Perhaps a better way of showing such behavior is by impact tests on specimens previously strained, either at room temperature or in the so-called blue-brittle range. Tests of this sort reflect material behavior at points of stress concentration such as notches, sharp corners and abrupt changes of section and thus are important in determining applicability of a material. Figure 3 shows the marked strain-aging behavior of bessemer steel as contrasted to open hearth; the effect is even more pronounced if the straining be performed in the 400 to 500 F. range.

Carbon Limits—An indirect consequence of the graphitization problem with carbon and carbon-molybdenum steels has been a general lowering of permissible carbon content in the alloy casting steels. Prior to 1946, most of the casting steels of ASTM A 157 and ASTM A 217 permitted carbon to a maximum of 0.30 percent. With the need for chromium additions for combatting graphitization and the desire to maintain welding characteristics, the newly developed alloys were specified usually with 0.20 percent maximum carbon. Thus casting steels have substantially the same composition and mechanical properties as the tubular products to which they may be joined. Along with this change also comes slightly improved ductility, toughness and creep strength.

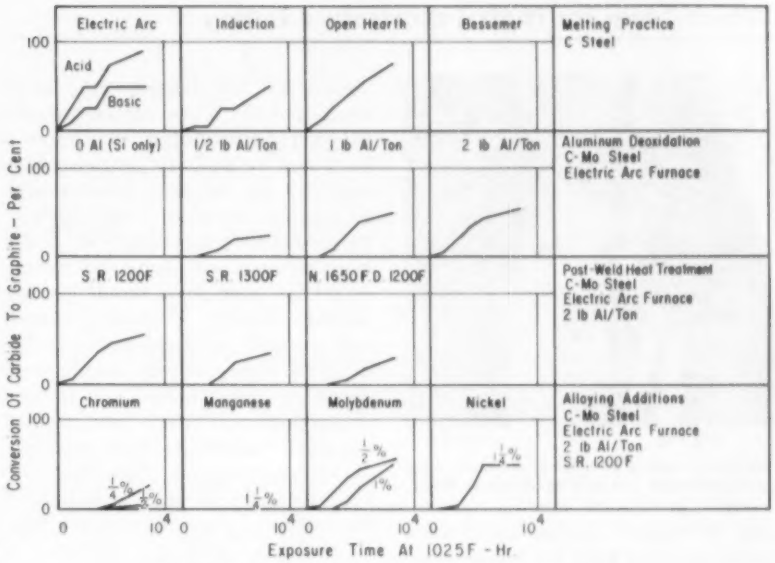

FIGURE 2—Graphite formation under various conditions.

Embrittlement of Ferritic Steels—While the large majority of carbon and low alloy steels in high temperature refinery service retain their desirable properties to a large degree, there have been instances reported of embrittlement occurring after extended periods of operation. This condition has been observed in carbon, carbon-molybdenum and 5 percent chromium: ½ percent molybdenum steels and could be expected to develop in other chromium-molybdenum alloy steels also. Generally the affected material shows no change in hardness or tensile properties but the impact resistance is decreased sharply. The results shown in Table 1 for a 5 percent chromium: ½ percent molybdenum steel pipe removed from service after 74,000 hours with a fluid temperature of 1020 F. demonstrate the effect.

TABLE 1

Effect of Heat Treatment on Impact Resistance of Embrittled 5% Cr½% Mo Steel

	Charpy Impact—Ft./Lb.
After service	18, 19½
Heated at 1300 F.—4 hours	55, 57
Heated at 1100 F.—4 hours	34
Normalized 1630 F., drawn 1300 F.	65, 62

These values also show that the condition can be removed by heating below the critical range or by normalizing and drawing. It is interesting to note that a substantial improvement

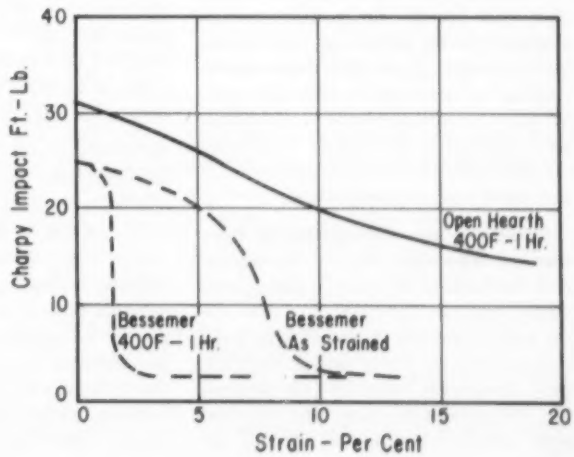

FIGURE 3—Strain-aging behavior of Bessmer and open hearth steels.

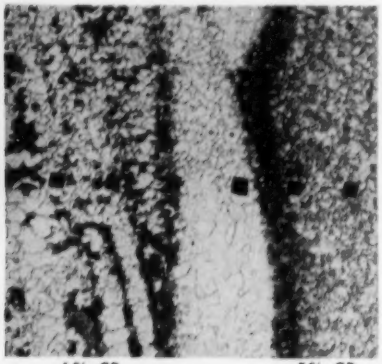

FIGURE 4—Carbon diffusion in dissimilar metal weld joints after post weld annealing at 1650 F.

may be realized by heating even a small amount above the service temperature.

This phenomenon is very similar in many of its aspects to temper embrittlement except that the latter occurs in a very short time, i.e., during the tempering portion of a heat treating cycle. In contrast, a sample of the restored 5 percent chromium: ½ percent molybdenum steel retained its impact properties even after 262 hours exposure at 950 F. It seems possible that the two types of embrittlement may stem from the same source but this need not be so. Investigators have attributed temper embrittlement to various causes among which may be listed changing carbide solubility with temperature and presence of residual impurity elements such as antimony, arsenic, phosphorus, tin and titanium. Molybdenum is generally considered to be a specific remedy for temper embrittlement but as much as ½ percent appears inadequate for the service embrittlement described herein. No positive metallographic evidence of an embrittling intergranular phase has been forthcoming in connection with this type of service embrittlement. It is fortunate in view of our lack of knowledge on this subject that the deficiency is not encountered more often.

Welding of Chromium-Molybdenum Steels—Most chromium-molybdenum steel refinery piping elements are joined by welding now. In the past it was not uncommon to weld some of these joints with austenitic steel electrodes, usually 25 percent Cr: 20 percent Ni alloy, and dispense with stress relieving. It should be pointed out that this procedure leaves alloys like the 5 percent chromium: ½ percent molybdenum steel in a hard and relatively notch-sensitive condition in the heat affected zone adjacent to the weld. While this procedure has been successfully employed in many cases with light wall tubing, its general application should be considered carefully. Probably trouble was avoided in these instances because of ability of the ductile weld deposit to absorb line strains. In light of developments which have yielded improved procedures and electrodes of compositions matching the base material, there seems to be little need for continued usage of austenitic steel electrodes for welding of ferritic steel piping except under unusual circumstances for field work.

For elevated temperature service above about 800 F., the practice of joining ferritic steel piping with austenitic steel welds presents another potential hazard. Where the austenite phase is in contact with ferrite, carbon will diffuse to the higher alloy (producing a carbide-rich zone at the interface) and away from the low alloy (leaving a weak decarburized area adjoining the carbide). The net result is a brittle zone immediately adjoining the fusion line which is subject to failure under unusual loading conditions. This same situation will result in a ferritic steel system if differences in chromium content exist between the weld and the base metal. Carbon diffusion is even evident in dissimilar metal joints after application of a post weld heat treatment above the critical range (Figure 4). In view of the danger attending an unexpected failure during refinery operations, use of dissimilar metal weldments should be weighed very carefully.

Since welding has become such an important part of refinery fabrication and erection, it is well to note that the newer welding techniques are applicable to the chromium-molybdenum steels even at the higher chromium levels. Automatic submerged arc welding is employed on a routine basis in shop fabrication. Special attention should be given to use of the inert gas shielded arc process for making the first pass of pipe welds without backing rings and with or without added filler metal or inserts. The process has particular merit where complete elimination of crevices and projections is desired.

Embrittlement in High-Chromium Steels—As noted previously, the high chromium steels are used to some extent because of their superior corrosion resistance. They are subject in varying degrees to a loss of ductility which has been termed "885 F. embrittlement" because its maximum effect is noted in this range. The 27 percent chromium steel is most susceptible to this form of deterioration. Material properties such as hardness, tensile strength and ductility undergo changes but the most profound effect is in impact resistance as may be seen in Table 2.

TABLE 2
Effect of Exposure at 850 F. on Impact Resistance of 27% Chromium Steel

	Charpy Impact Ft./Lb.		
	80 F.	200 F.	850 F.
Original—annealed	4½	33	38
Aged at 850 F. for 1000 hours	0	0	6½

The 27 percent chromium iron tends toward brittleness even in the annealed condition but considerable toughness is available at slightly higher temperatures. After aging at 850 F., however, the material becomes quite brittle, both at room temperature and elevated temperatures. There is neither microscopic or X-ray diffraction evidence as to the cause of the embrittlement. This condition may be removed by heating in the 1000 to 1200 F. range. Prolonged heating, however, between 1000 and 1400 F. results in sigma phase precipitation which, in turn, locally depletes chromium from the matrix and reduces corrosion resistance. This process may be reversed and toughness together with corrosion resistance restored by heating above 1500 F. and cooling rapidly.

No completely satisfactory explanation of 885 F. embrittlement is available at this time. Cold working prior to exposure in the embrittling range enhances the effect and suggests a relationship to sigma phase formation. Similar changes occur in 17 percent chromium steel but to a lesser degree. The AISI Type 410 steel (12 percent chromium) seems to be entirely free of such embrittlement but the aluminum-bearing modification of this alloy, Type 405, is susceptible to some

extent though possibly in a somewhat lower temperature range. Application of the high chromium steels to elevated temperature service is understandably restricted because of the embrittling structural changes.

Experience with Austenitic Steels—Apart from usage where only corrosion resistance is desired, the chromium-nickel-iron alloys are employed for extreme pressure and temperature service. Although high creep and rupture strength is indicated by laboratory tests, these materials suffer from some serious defects. Lack of structural stability in elevated temperature service as evidenced by intergranular carbide precipitation and sigma phase formation, both of which reduce corrosion resistance and promote embrittlement, are well known. A relatively stable carbide structure for short exposures to high temperatures, as required for welding applications, is obtainable through the addition of carbide forming elements like columbium and titanium. A measure of immunity from the deleterious effects of carbide precipitation is available through utilization of what has been termed a stabilizing heat treatment. In this treatment, carbide is permitted to precipitate and agglomerate at a high enough temperature (1525 to 1650 F.) to allow diffusion and homogenization of the chromium content. Thus, corrosion resistance is not seriously impaired.

In casting grades, the wider limits on chemical composition make for greater variability of structure and, hence, of properties. Fully austenitic steel is obtained if austenite formers (Ni, C, N, Mn) run high while ferrite formers (Cr, Si, Mo, Cb, Ti) run low. The structure may contain considerable ferrite if the reverse is true and it is from this ferrite that sigma phase forms most readily. The effect of exposure at 1200 F. on impact properties of two of the more popular casting grades of austenitic steels is shown in Figure 5 and a comparison of the loss of toughness in the high and low nickel modifications of Grade CF8M steel illustrates this point.

Welding of austenitic steels in light sections has not posed any particular problem, especially if stabilized or extra low carbon grades are used to avoid carbide precipitation. With heavier wall thicknesses, increased restraint on the weld deposit has led to development of microcracks in the weld and, in some cases, to longer or macrocracks. Fully austenitic steel weld deposits are most susceptible to formation of microcracks and the condition may be alleviated by balancing the composition of the weld deposit so it contains a small amount of ferrite. A structure of this type is, of course, subject to the same deterioration at elevated temperatures as similar casting steels. In making welds, use of preheat is usually avoided, interpass temperature is limited to 250 F. and normally no stress relieving is practiced. If corrosion resistance or dimensional stability is an important consideration, weldments may be fully annealed or given a stabilizing heat treatment.

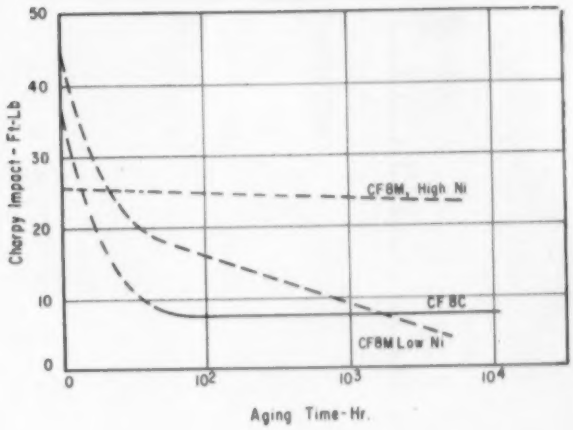

FIGURE 5—Exposure at 1200 F affects the impact properties of Austenitic steels.

In heavy wall AISI Type 347 steel steam power piping, still another difficulty has been encountered in the form of base metal cracking a short distance from the fusion line. Cracking of this sort is more prone to occur in coarse grained material. To date no such trouble has been reported in refinery piping but it behooves engineers to take cognizance of the possibility of such an occurrence.

Failures of cast austenitic steel valve bodies in thermal cyclic processes have been reported by Holmberg[4] and attributed to thermal shock conditions. In this service, the inner surfaces of the heavy wall bodies are subjected to rapid heating by hot fluid and, because of the poor thermal conductivity and high expansivity of austenitic steel, the material upsets itself. Later, as the temperature equalizes, the inner skin is under a tensile stress of greater magnitude than if the heating had been accomplished slowly and uniformly. Repeated cycling of this sort leads to internal cracking.

This explanation of the failure seems quite plausible although alternate suggestions have been made involving (1) stress corrosion by a high boiling point condensate or (2) a thermal fatigue process with lowered strength under cycling temperature conditions. While engineers may not agree as to the mechanism, it has been observed that use of ferritic steel and lessening the temperature swings give longer valve life.

During shutdown periods, austenitic steels are subject to stress corrosion failures, especially in the presence of chloride ions. It is not always readily apparent where the two essential ingredients of such a process, stress and a specific corrosive agent, come from. Sometimes the high coefficient of expansivity of austenitic steels (approximately 1½ times that of ferritic steels) is the source of stress while, in other instances, residual stresses in weldments may be responsible. Corrosive agents may come from brackish water used for hydrostatic pressure testing, cleaning reagents or condensates. Applications involving ferritic steels clad with austenitic alloy warrant examination of the possibility of developing stress corrosion type failures.

Original presentation was before the ASME Petroleum Mechanical Conference, Dallas, Sept. 24, 1956.

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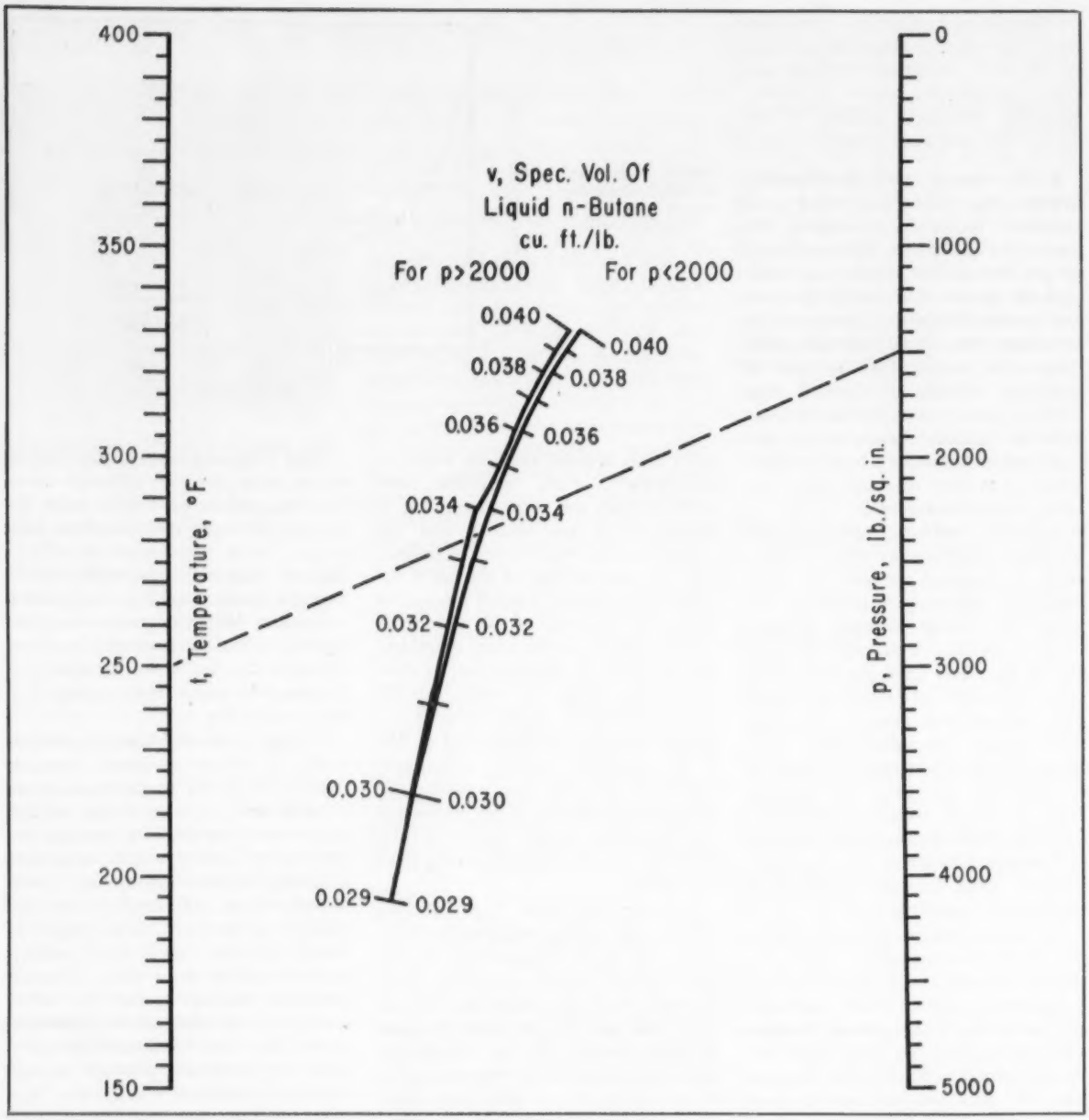

Use this Nomograph for . . .

P-V-T for Liquid Butane

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Tuscaloosa, Alabama

BASED ON reliable data,[2] the accompanying nomograph presents P-v-t relationships for liquid n-butane conveniently and accurately. Above and below a pressure of 2000 pounds per square inch, pressure is linear with temperature at specific volumes between 0.029 and 0.040 cubic foot per pound.

The use of the chart, which was constructed by means of well-known methods,[1] is illustrated as follows: What is the specific volume of liquid n-butane at 250 F and 1500 pounds per square inch? Connect 250 on the t-scale and 1500 on the p-scale with a straight line and note the intersection with the right-hand branch of the v-scale (for pressures below 2000 pounds per square inch) at 0.0335 cubic foot per pound.

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When lead is attacked by a corrosive material, a protective film is formed. In the lead lining shown here, strips of sheet lead are used to protect the studs which hold the lining in place

How to Maintain and Inspect Lead Linings

Resistance of lead to chemical attack depends on the protective film formed when the lead corrodes. Keeping this film intact calls for proper inspection and maintenance.

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DESPITE THE FACT that more than one-third of the lead consumed in this country is used for protection against corrosion, lead is by its chemical nature a corrodable metal. Oddly enough, it is this corrosive character of lead that accounts for its well-known resistance. The reason is simple enough. When lead is attacked by a corrosive medium, a compound of the lead and the corrosive forms immediately as a film. In this respect, lead differs little from aluminum, stainless steels and other materials which owe their corrosion resistance to protective films.

Corrosion Characteristics of Lead—Generally speaking, lead has good resistance to neutral solutions where lead carbonate and possibly oxide are corrosion products. It has fair resistance to alkaline solutions in which these are soluble. Experience has shown that lead is commercially resistant to chromic, sulfuric, sulfurous and phosphoric acids; that it is subject to corrosion at somewhat higher rates by hydrochloric and hydrofluoric acids and that it is susceptible to being strongly corroded by acetic, formic and nitric acids. Nitrate salt solutions are moderately corrosive, whereas carbonate solutions are not.

After establishing that lead can be used with a particular corrosive, it is important to keep in mind that lead depends for this resistance on its protective film. It is true that a good protective film is self-healing but by continually taking advantage of the self-healing characteristics and losing sight of the fact that the self-healing process involves the corrosion of a portion of the metal, the result may be premature failing of the lining. Therefore, conditions such as excessively fluctuating concentration or temperature, the introduction of entrained particulate matter, or mechanical abuse, will all have a destructive effect on lead's normally protective film and thus its ability to handle corrosives efficiently.

In dealing with mixed corrosives oftentimes one of the constituents will aid in the formation of a protective film while the other will dissolve the film. Whether lead can or cannot be used under these conditions depends on the proportion. For example, mixed hydrochloric and sulfuric acids

have been handled successfully in lead when the sulfuric acid concentration was above 15 percent and the hydrochloric acid below 5 percent. Temperature, too, will affect this ratio.

There have been occasions when lead would not perform satisfactorily because a sufficiently protective film could not develop. For example, in a lead lined sulfuric acid vessel maintained partially filled, it was found that corrosion proceeded at a much more rapid rate in the vapor zone. The films that formed here as a result of the presence of oxygen were less stable than pure sulfate films and therefore failed to prevent corrosion. This situation was corrected by periodically raising the level of the liquid in the vessel long enough for a lead sulfate film to form. In general it is a better practice to minimize vapor-zone areas by maintaining vessels as completely full as possible.

In the case of corrosives which, in themselves, do not readily form a protective film and will not dissolve lead sulfate, it is often possible to make the lining corrosion proof by swabbing the lead with dilute sulfuric acid or, if possible, filling the vessel with it for a short period of time in order to establish a protective sulfate film.

(At 70 F. in 25 to 35 percent sulfuric acid chemical lead will form a complete sulfate film in from 9 to 10 hours. Under the same conditions 9 percent antimonial lead forms a sulfate film in from 1 to 1½ hours.)

When specifying antimonial lead, do not lose sight of the fact that while antimonial lead is harder and stronger than chemical grade lead, this condition exists only up to about the boiling point of water. As the temperature increases, the physical strength of 6 percent antimonial lead drops until at 248 F. it is equal to chemical grade lead; above this temperature the antimonial lead actually becomes softer than chemical lead. This is an important consideration when processing temperatures are raised without changing the processing equipment. Under these conditions it may be necessary to increase the supporting structure to compensate for the strength drop.

Inspecting and Testing Lead Linings—Higher pressures and temperatures and higher corrosive concentrations have all focused attention on the need for the inspecting and testing of chemical processing equipment, particularly prior to being put into service—and lead is no exception. Sheet lead installations may be tested for imperfect welds or pinhole penetration with fluorescent penetrants or dye penetrants. Both of these depend upon capillary absorption in the defect of special chemicals and subsequent "development" of the chemicals to locate the defect. It has also been found practical to pump dyed kerosine between a lead lining and the outer shell and inspect the inside for the presence of the kerosine. Another technique is to pump freon-loaded air into the area between the shell and the lining. The presence of gas escaping through any perforations can be readily detected with a halide torch.

Bonded lead linings are usually tested for bond discontinuity, pinholing or porosity. The "acid wash test" is generally used for the latter two. After freeing the lead surface of any oil or grease films, a dilute solution of hydrochloric acid (15 percent HCl) is applied and allowed to remain for 12 to 24 hours. On inspecting, a wet spot indicates surface porosity or a pinhole that has not penetrated, whereas rusty discoloration indicates a pinhole that extends through the lead to the steel. Repairs are easily made by removing the lead from this area and rebonding by hand.

Bond discontinuity, on the other hand, cannot be detected by the acid wash test. In this case ultrasonics may be used, relying on either "resonance" or "pulse" methods. In the "resonance" method the test instrument transmits an ultrasonic wave into the metal and the reflected waves are detected. When the lead is well bonded the waves are not reflected by the steel-lead interface, whereas definite signals detected audibly or visibly indicate unbonded or partially bonded areas.

In the "pulse" method vibrations are sent through the metal until it strikes a flaw and is reflected whereas the rest of the waves travel on until they hit the opposite surface and are reflected. Inspection by ultrasonics is made in most cases from the steel or outside of the vessel. This technique also serves as a nondestructive method for checking the thickness of the lead lining.

Another commercially practical method for locating unbonded areas, though limited to pressure vessels, is to seal the vessel and raise the internal temperature by steam or otherwise, to about 500 F., cool as rapidly as possible and examine for lead bubbles whose presence would indicate lack of bond.

Radiographic techniques have been developed for testing brick and lead lined vessels in those cases where it is impractical to remove the brick. Radiography is practical for locating internal flaws or porous areas but does not lend itself well to bond detection.

This article is a condensation of a paper presented at the symposium on Control of Corrosion in the Chemical Industry, sponsored by the Niagara Frontier Section of the National Association of Corrosion Engineers and the University of Buffalo, Buffalo, N. Y., May 10, 1956.

Meet the Author

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Simplify Boiler Water Treatment

Here is a rational method for boiler saline treatment to prevent the common problems usually associated with steam generation.

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BEFORE GOING into methods of treating boiler water, it is well to review the objectives of boiler water treatment. These are:

1. To prevent corrosion
   - A. Of boiler surfaces
     - a. By pH control
   - B. Of steam and condensate lines
     - a. By oxygen removal (Sulfite or organic)
     - b. By carbon dioxide removal and neutralization
   - C. By intercrystalline cracking
     - a. By inhibitors
2. To prevent scale
   - A. By external treatment of feed water
     - a. Lime-soda (hot or cold)
     - b. Phosphate
     - c. Ion exchange
     - d. A combination of the above
   - B. By internal treatment
     - a. Soda ash or sodium hydroxide
     - b. Phosphates
     - c. Organics
3. To prevent carry-over
   - A. By foaming and priming
     - a. Adjust surface tension—organics
   - B. By mechanical carry-over
     - a. Adjust total dissolved solids
   - C. By carry-over in steam solution
     - a. External treatment
     - b. Internal treatment

1-A. To prevent corrosion of boiler surfaces: It has been found that practically no corrosion of submerged boiler surfaces will occur if the pH of the boiler salines is maintained above 10.5.[8,28] Since a higher pH than this should be maintained to prevent scale, this condition is automatically maintained.

1-B. To prevent corrosion of steam and condensate lines: The substances which cause corrosion of steam and condensate lines as well as non-submerged boiler surfaces are oxygen and carbon dioxide. In many power plant installations the bulk of the oxygen is removed either in a hot process softener or a deaerating feedwater preheater. Whether or not mechanical oxygen removal is practiced, supplimentary chemical treatment is necessary. The chemicals used, called "oxygen scavengers," are sulfites which are introduced either as sulfur dioxide[18] or sodium sulfite[7,20,23] and are suitable up to boiler pressures of about 900 pounds per square inch; organic materials of the pyrogallol type;[14] and hydrazine.[24] In every case it is desirable to maintain an excess of about 15 ppm of active ingredient.

The other corrosive element found in steam is carbon dioxide. Free carbon dioxide rarely exists in boiler feed water, especially if it has gone through a deaerating heater. However, most feed waters contain either bicarbonates, carbonates or both. At boiler temperatures, the bicarbonates suffer a complete breakdown to carbonates releasing carbon dioxide, thus: $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$, and carbonates decompose to the extent of 80-90 percent, thus: $Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$.

Since these reactions take place within the boiler, the carbon dioxide released goes over with the steam. Little boiler or steam line corrosion results, but severe condensate return line corrosion can result from as little as 5 ppm carbon dioxide.

Ammonia or ammonium salts have been employed in this capacity. However, since they have a tendency to attack copper or copper alloys, their use is limited. To avoid such attack, organic amines have been more extensively employed. In general, two types of amines can be used; neutralizing amines which react with the carbon dioxide to form non-corrosive compounds, and filming amines which lay down protective films. The ones most commonly used are cyclohexylamine, morphaline and benzylamine.[4] These may be added directly to the boiler in quantities sufficient to maintain the pH of the condensate at 7.0. In order to be economical they must be used in a boiler having a low percentage of make-up water. The filming amines in addition to reacting with the carbon dioxide, lay down a protective film on exposed metal surfaces. Considerably less concentration is required and is best determined by trial and error. They have the additional advantage that they can be injected directly into the steam line at points where corrosion is found. For the most part they are propriarity compounds.

In addition to amines, polyphosphates[16] and chromates[3] have been injected into the steam lines with some success.

1-C. To prevent corrosion by intercrystalline cracking: Its cause is unknown and most of the proposed salt ratios have been proved useless.[29] The most recent data indicates that phosphates, nitrates and organics are the best inhibitors for this type failure. Phosphates are suitable only in the absence of hydroxides,[10] a condition seldom encountered in boiler salines. Organics of the lignin type have been found beneficial in many cases but not enough work has been done on them to permit generalization. Perhaps the most successful treatment has been sodium nitrate which can be used at pressures up to 700 psi. Recommended quantities are: Sodium nitrate equal to 40 percent of the total alkalinity calculated to sodium

hydroxide[22] or $\left(\frac{NO_3}{M - PO_4}\right)$ $2.14 = k$ .....(11)

NO_3 = ppm nitrate
M = ppm total alkalinity as $CaCO_3$
PO_4 = ppm phosphates
k = Factor depending upon boiler pressure

0-250 psi	k = 0.2
250-450 psi	k = 0.25
450-700 psi	k = 0.4

2-A. To prevent scale by external treatment of feed water: It is beyond the scope of this paper to discuss in detail the various methods of external treatment. However, the limitations of internal treatment dictate to a certain extent the type of external treatment. The residual hardness of water treated by various methods is:

Cold lime soda.....30-40 ppm $CaCO_3$
Cold lime soda plus sodium aluminate...15-25 ppm $CaCO_3$
Hot lime soda.....10-15 ppm $CaCO_3$
Hot phosphate.....5-10 ppm $CaCO_3$
Ion Exchange..less than 1 ppm $CaCO_3$

What treatment to use with what boiler depends upon a number of factors—availability of external treatment, permissible length of boiler runs, down time for cleaning, etc.

Maximum Hardness of Feed Water

Boiler Type	Capacity Pounds Hr.	Pressure Psi.	Hardness, $CaCO_3$ ppm
Scotch	20,000	250	200
Bent Tube	20-50,000	500	50
High Pressure	50-300,000	1900	0

2-B. To prevent scale by internal treatment: High alkalinity in boilers is necessary, not to prevent scale formation, but to prevent the scale formed from adhering to the boiler surfaces.[2] A pH of 11-11.5 is desirable and is maintained by holding the hydroxide alkalinity at 10 percent of the total dissolved solids[15] but not to allow it to drop below 170 ppm calculated as calcium carbonate.[21] Many waters contain enough natural alkalinity to produce these quantities in boiler salines by decomposition of sodium carbonate.

If the natural alkalinity is not high enough it can be supplemented by the addition of alkaline materials such as sodium hydroxide, sodium carbonate or trisodium phosphate. Although sodium carbonate addition is more convenient, the subsequent release of carbon dioxide is undesirable. Sodium hydroxide is preferred. Trisodium phosphate is used only in borderline cases.

The second requirement for internal treatment is the addition of a precipitating agent. In the past sodium carbonate has found wide use,[25] it is being almost universally replaced by sodium phosphate. References too numerous to mention[15] e.q., recommend an excess of 40 ppm PO_4. Sodium fluoride has been used experimentally[27] and one installation is known to use acetic acid.[1] Anhydrous disodium phosphate is the chemical usually added.

The third requirement is a sludge conditioning agent. In low pressure boilers tannin, quebracho, cutch, etc., can be used. In high pressure boilers, lignin compounds are preferred. The American Railroad Engineers Association recommend that the organic content as determined by the Folin-Dennis test[12] be maintained at 20 percent of the total alkalinity.

3-A. To prevent carry-over by foaming and priming: The causes of foaming in boilers are complex and little is known about them. Oil, especially steam cylinder oil, when introduced into boiler feed water often produces foaming. The obvious method of eliminating this is to take steps to prevent oil from entering the boiler. Filters and centrifugal separators are valuable in this case.[9]

In most other cases the addition of a few parts per million of an organic of the polyamide type have proved successful.[17]

3-B. To prevent carry-over by mechanical means: This is the result of the bursting of bubbles at the water surface in the absence of foaming. This can be best prevented by maintaining the proper concentration of total dissolved solids in the boiler water. Too high a concentration leads to foaming and too low a concentration leads to mechanical carry-over. The presence of most organics is helpful.[26] The American Boiler Manufacturers Association recommends the following limits of total dissolved solids:[6]

Boiler pressure, psi gage	ppm total solids
0- 300	3500
301- 450	3000
451- 600	2500
601- 750	2000
751- 900	1250
901-1000	1500
1001-1500	1000

3-C. To prevent carry-over in steam solution: If the total dissolved solids are kept in the range given above there will be little danger of carry over of salt in steam solution. However in high pressure boilers especial consideration must be given to silica. It has been proven that silica is soluble in steam[25] and will deposit at points of pressure drop such as on turbine blades. Maximum allowable silica concentrations in boiler salines are:[19]

Pressure psi	Max. SiO_2, ppm
150	150
250	100
400	75
600	50
900	25
1200-2000	5

Since there is no known satisfactory method of removing silica by internal treatment, external methods must be applied. Among these methods are adsorption by magnesium compounds[5] and ion exchange.[13]

A recapitulation of the use of organics are:

1. Sludge conditioners: lignin, starch, mannuronates, tannins, glucosates, etc.
2. Oxygen scavengers: pyrogallols
3. Embrittlement inhibiters: lignins
4. Antifoams: Polyamides
5. Carbon Dioxide neutralizers: Organic amines

From the above discussion, it is possible to formulate the ideal composition of the dissolved solids in the salines of a boiler of any pressure. These compositions, given in Table 1, fill the following requirements:

1. Excess phosphate to prevent scale formation
2. Excess sulfite to prevent oxygen corrosion
3. Minimum silica to prevent carry-over
4. High pH to prevent scale and corrosion
5. Enough Nitrate to inhibit embrittlement

6. Enough organics to assure proper sludging

These compositions do not provide for the following conditions:

1. Inhibit carbon dioxide corrosion
2. Inhibit oxygen corrosion above 900 psi
3. Inhibit foaming
4. Inhibit against embrittlement above 700 psi.

Having determined the composition of the salines for any operating condition, it is then possible to set up a series of tables giving the permissable concentrations of non scaling salts in the boiler feed water for any blowdown condition. These analyses are shown in Table II.

The use of these tables will greatly simplify many boiler and water treatment design problems. Given any boiler design, the feed water composition can be determined or given any water, the boiler design which will handle it can be determined.

Example I. A 500 psi boiler capable of producing 250,000 pounds of steam per hour operates at 5 percent blowdown and 75 percent condensate return. What composition is permissable and what treatment is necessary for the salines, feed and make up water?

From line 3, Table 1, the composition of the salines is:

	ppm
Total alkalinity	250
Sodium hydroxide	160
Sodium carbonate	50
Trisodium phosphate	69
Sodium sulfite	24
Sodium nitrate	41
Silica	75
Other dissolved solids	2081
Organics	50

The composition of the boiler feed can be taken from line 3, section 3, Table 2:

	ppm
Total alkalinity, min.	12.5*
Sodium hydroxide, min.	8.0
Sodium carbonate, min.	2.5
Silica, max.	3.7
Other dissolved solids, max.	104.1
Hardness as $CaCO_3$, max.	10 (Section 2-A)

*Exclusive of alkalinity associated with the hardness.

The necessary treatment:

	ppm	lbs. per 1,000,000 gal.*
Trisodium phosphate	3.5	29.16
Sodium sulfite	1.2	10.00
Sodium nitrate	2.0	16.66
Organics	2.6	21.66

*ppm × 8.33 = lbs. per 1,000,000 gal.

If the total alkalinity of the feed water is below the 12.5 ppm minimum, it will be necessary to add enough sodium hydroxide or sodium carbonate to raise it to that figure.

Since 75 percent of the feed water is steam condensate which contains no dissolved solids, the make up water can contain 100÷(100—75) or four times the dissolved solids in the feed water. Thus the permissable solids concentration of the makeup water is:

	ppm
Total alkalinity, min,	50.0
Sodium hydroxide, min.	32.0
Sodium carbonate, min.	10.0
Silica, max.	14.8
Other dissolved solids, max.	416.4
Hardness as $GaCO_3$	40.0

*Exclusive of alkalinity associated with hardness

If the raw water available meets the hardness, TDS and silica specifications, it can be used as is, otherwise a cold lime-soda treatment is the minimum that can be used.

Example II. A ion exchange softened water has a silica content of 5 ppm and a dissolved solids content of 150 ppm exclusive of alkalinity. Can it be used as feed water for a 900 psi boiler?

From section 5, Table 2, it can be seen that the ratio of dissolved solids to silica is 123.8/2.5 or 49.52, whereas the ratio of the water under question is 150/5 or 30. Thus the silica content is the limiting factor. Referring to line 5, Table 1, it is seen that the permissible silica concentration is 25 ppm. Thus, in order to use the water without condensate it would be necessary to operate the boiler at (5/25) × 100 or 20 percent blowdown. This would undoubtedly be prohibitive.

Referring again to line 1, section 5, Table 2, the amount of condensate return necessary to operate the boiler at 1 percent blowdown can be calculated from the formula:

$$100 - (0.2/5 \times 100) = 96 \text{ percent}$$

Similar calculations for other blowdown conditions show the necessary condensate return to be:

percent blowdown	percent condensate return
1	96
2	90
5	76
10	50

If the silica concentration were in the range of 1.5 ppm, the dissolved solids become the limiting factor for the use of this water. By calculations similar to those for silica, the necessary condensate return for various blowdown rates is found to be:

percent blowdown	percent condensate return
1	91.7
2	83.5
5	58.7
10	17.5
12.2	0

Example III. Available raw water has the following analysis:

	ppm
SiO_2	4
$Ca(HCO_3)_2$	101
$Mg(HCO_3)_2$	17
$NaHCO_3$	42
Na_2SO_4	36
NaCl	63

How must this water be treated to be used as makeup for a 1300 psi boiler operating at 85 percent condensate return and 2 percent blowdown.

The first step in the solution of this problem is to determine the allowable composition of makeup water for the boiler. From line 2 section 7, Table 2, the feed water composition is:

Silica, Max.	0.1	ppm
Total Alkalinity, Min.	3.4	
Other solids, max.	15.6	
Hardness, max.	1.0	(Section 2-A)

TABLE 1

PRESSURE	(1) Min. Na_3PO_4	(2) Min. Na_2SO_3	Max. SiO_2	(3) Min. NaOH	Na_2CO_3	(4) $NaNO_3$	Other Solids	M	(5) Organics
0- 300	69	24	100	224	70	41	2972	350	70
301- 450	69	24	75	192	60	41	2539	300	60
451- 600	69	24	75	160	50	41	2081	250	50
601- 750	69	24	50	128	40	41	1648	200	40
751- 900	69	24	25	108	36	..	1238	170	34
901-1000	69	..	25	108	36	..	1012	170	34
1001-1500	69	..	5	108	36	..	782	170	34

(1) 40 ppm PO_4
(2) 15 ppm SO_3 =. An organic can be substituted
(3) 10% TDS as M alkylinity with a minimum of 170 ppm.
(4) Based on Betz formula
(5) Sludge conditioning only, lignin type

Since the feed water consists of 85 percent condensate and 15 percent makeup, the allowable composition of the makeup water will be 100/15 times the composition of the feed:

Silica	0.6 ppm
Total Alkalinity	22.64
Other solids	104.
Hardness	6.

It can be seen immediately that the hardness reduction can be accomplished only by ion exchange or hot phosphate softening. On the other hand, the silica reduction can be accomplished only by ion exchange or hot lime-soda softening. Thus the water must be conditioned by a combination treatment. Three possibilities present themselves:

1. Hot lime-soda followed by hot phosphate
2. Lime-soda (hot) followed by ion exchange

3. Deionization

The next step is to compare the actual treated water with the allowable makeup waters. For case 1, Hot lime-soda followed by hot phosphate; 90 percent silica reduction can be expected, all the magnesium salts and all but 6 ppm of the calcium salts will be precipitated, and about 5 ppm trisodium phosphate will be added, and the sodium bicarbonate will be converted to sodium carbonate. The analysis will look like:

	ppm
SiO_2	0.4
Total alkalinity $\frac{100}{106} \times 42$	39.6
Other solids	99.0
Hardness	6.0

The excess alkalinity is (39.6—22.64) = 16.96 ppm which must be added to the other solids; 99.0 + 16.96 = 115.96 which is slightly high. Since this method allows very little margin of safety in the silica, hardness and dissolved solids, its use would be risky.

In the second case, hot lime-soda followed by ion exchange; silica can again be reduced to 0.4 ppm; all the magnesium salts and all but 15 ppm of the calcium salts will be precipitated by the lime-soda softener and that 15 ppm will be converted to sodium carbonate by the ion exchanger leaving a hardness of less than 1 ppm. The sodium bicarbonate will be converted to sodium carbonate and the other salts will be unaffected. The analysis will be:

	ppm
SiO_2	0.4
Total alkalinity $(42 + 15) \times \frac{100}{106} =$	54
Other solids	99
Hardness	1

The excess alkalinity is (54—22.64) = 31.56 ppm which must be added to the other solids; 99 + 31.56 = 130.56 ppm which is too high to use under the conditions specified. This treatment could be used if a higher percent blowdown could be tolerated.

Thus it will be seen that deionization, using a silica removing material is the preferred treatment in this case.

TABLE 2

Percent Blow	Na_3PO_4	Na_2SO_3	SiO_2	NaOH	Na_2CO_3	$NaNO_3$	Other Solids	M	Organic
0—300 PSI									
1	0.7	0.3	1.0	2.2	0.7	0.4	29.7	3.5	0.8
2	1.4	0.5	2.0	4.5	1.4	0.8	59.4	7.0	1.4
5	3.5	1.2	5.0	11.2	3.5	2.0	148.6	17.5	3.6
10	6.9	2.4	10.0	22.4	7.0	4.1	297.2	35.0	7.0
301—450 PSI									
1	0.7	0.3	0.7	1.9	0.6	0.4	25.4	3.0	0.6
2	1.4	0.5	1.5	3.8	1.2	0.9	50.8	6.0	1.2
5	3.5	1.2	3.7	9.6	3.5	2.0	127.0	15.0	3.0
10	6.9	2.4	7.5	19.2	6.0	4.1	253.9	30.0	6.0
451—600 PSI									
1	0.7	0.3	0.7	1.6	0.5	0.4	20.8	2.5	0.6
2	1.4	0.5	1.5	3.2	1.0	0.8	41.6	5.0	1.0
5	3.5	1.2	3.7	8.0	2.5	2.0	104.1	12.5	2.6
10	6.9	2.4	7.5	16.0	5.0	4.1	208.1	25.0	5.0
601—750 PSI									
1	0.7	0.3	0.5	1.3	0.4	0.4	16.5	2.0	0.4
2	1.4	0.5	1.0	2.6	0.8	0.9	33.0	4.0	0.8
5	3.5	1.2	2.5	6.4	2.0	2.0	82.4	10.0	2.0
10	6.9	2.4	5.0	12.8	4.0	4.1	164.8	20.0	4.0
751—900 PSI									
1	0.7	0.3	0.2	1.1	0.4	....	12.4	1.7	0.4
2	1.4	0.5	0.5	2.2	0.7	....	24.8	3.4	0.6
5	3.5	1.2	1.2	5.4	1.8	....	61.9	8.5	1.8
10	6.9	2.4	2.5	10.8	3.6	....	123.8	17.0	3.4
901—1000 PSI									
1	0.7	....	0.2	1.1	0.4	....	10.1	1.7	0.4
2	1.4	....	0.5	2.2	0.7	....	20.2	3.4	0.6
5	3.5	....	1.2	5.4	1.8	....	50.6	8.5	1.8
10	6.9	....	1.5	10.8	3.6	....	101.2	17.0	3.4
1001—1500 PSI									
1	0.7	....	0.05	1.1	0.4	....	7.8	1.7	0.4
2	1.4	....	0.1	2.2	0.7	....	15.6	3.4	0.6
5	3.5	....	0.25	5.4	1.8	....	39.1	8.5	1.8
10	6.9	....	0.5	10.8	3.6	....	78.2	17.0	3.4

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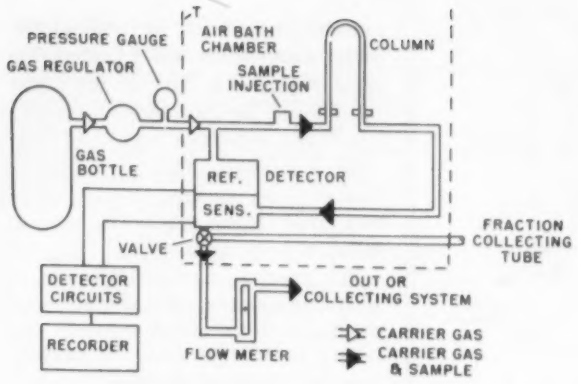

FIGURE 1—Flow scheme for gas chromatography instrument: Accuracy of a mass spec at a lower investment.

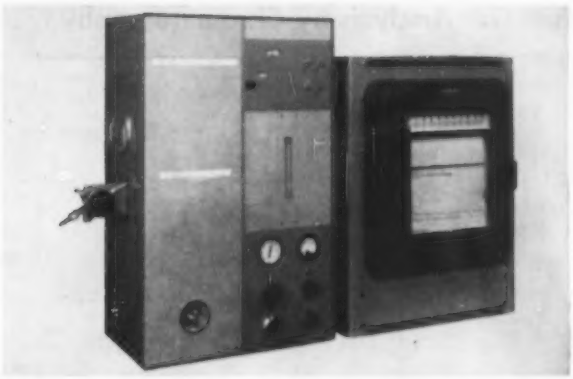

FIGURE 2—Instrument used for the gas analysis: Precision gas sampling valve is mounted on left side.

Fuel Gas Analysis by Chromatography?

It's a more accurate method than Orsat and cheaper than mass spectrometry.

Vincent J. Coates
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FIRST REPORT on fuel gas analysis by chromatography shows favorable promise. Most common method of analysis in use today for gases is the Orsat apparatus. Instruments of this type, although inexpensive, are not very sensitive and are capable of providing analysis of only a few components in a mixture.

Mass spectrometers are capable of excellent separation, providing accurate analysis of as many as 20 components, but are quite expensive and require skilled operators if consistent results are to be obtained.

Gas chromatography instrumentation is capable of equalling, or exceeding the analytical capabilities of mass spectrometers while requiring an investment not far in excess of that required for an Orsat apparatus.

Fuel gases contain components which boil over a wide range. For the analysis of hydrogen, nitrogen, carbon monoxide, methane, ethane, carbon dioxide, and propane, a two meter, stainless steel column packed with silica gel was chosen (Figure 2). Components heavier than propane have very long retention times and emerge from this column as very broad bands with very weak peak heights in the concentrations encountered here.

Very heavy components present in trace quantities may actually remain in the column during room temperature operation but can be chased out by raising the column temperature for a short while. Using this method of regeneration every 100 analyses or so, the column life can be maintained practically indefinitely and the column can be used with reproducible results for months or even years.

For the analysis of the heavier ends (Figure 3), a liquid partition column packed with 25 percent by weight tetraisobutylene (B.P. 200 C.) coated on amorphous silica (acid washed and sieved 60-100 mesh) was chosen. Two 2-meter stainless steel columns were used in series for best separation. The partition method, as distinct from the adsorption method, tends to produce more symmetrical band shapes for the higher boiling hydrocarbons.

The change from adsorption to partition columns requires only a few minutes. It is estimated that the complete separation of a mixture of fuel gases, hydrogen through pentanes, should require not more than 60 minutes. The separation of hydrogen through propane required about 30 minutes.

Analytical Procedure—Both band area and peak height are closely linear functions of concentration and can be used as a means of measuring

Fuel Gas Analysis by Chromatography? . . .

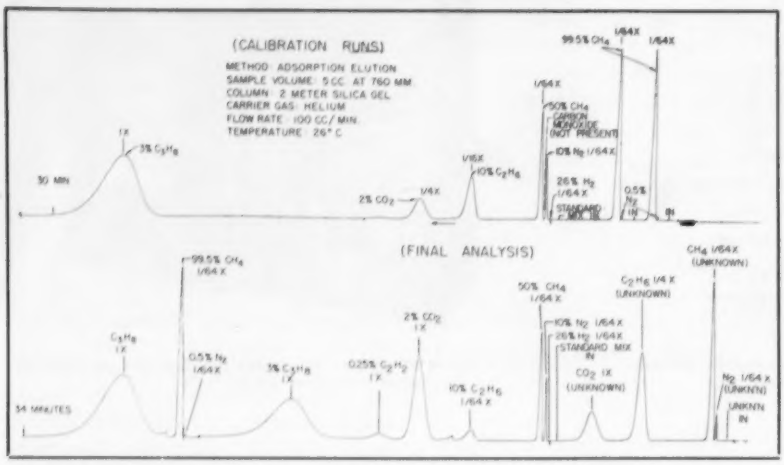

FIGURE 3—Natural gas analysis of light ends: Components heavier than propane have very long retention times.

component concentration. Several methods of utilizing these measurements to obtain analyses of mixtures are employed. The method chosen for this problem was the "calibration using known standards" method.

From known mixtures under reproducible conditions, calibration curves of peak height versus concentration are plotted for each component. By obtaining a chromatogram of the unknown mixture under the same instrumental conditions and measuring peak heights, concentrations are read directly from the calibration curves.

Taking all possible sources of instrument error into account, it can be conservatively estimated that a measurement precision of 1 percent of the amount present can be realized for major components and 4 percent for trace components. This accuracy can be attained directly without complicated and expensive control of ambient conditions. This performance, however does not take into consideration errors in the original calibration mixtures or operator error.

For routine repetitive analyses, where time can be profitably spent in setting up initial conditions and obtaining calibration data, the calibration using known standards method should be used. It has the overriding advantages of speed, simplicity, and accuracy. It seems ideally suited for fuel gas analysis.

Natural Gas Analysis—Natural gas contained under pressure in a cylinder was analyzed using gas chromatography. In order to set up the analysis, separation of all components was accomplished by a combination of adsorption and liquid partition principles. Chromatograms were obtained using a two meter stainless steel column filled with silica gel adsorbent (Figure 2) and two 2 meter liquid partition columns filled with tetraisobutylene on amorphous silica as the stationary phase (Figure 3).

HOW THE INSTRUMENT WORKS

A schematic flow diagram for this instrument is shown in Figure 1. Carrier gas is supplied to the system from an external gas cylinder equipped with a pressure regulator. Helium is normally used because of its high thermal conductivity and inertness. Nitrogen or dry air may be used where high sensitivity is not required.

The carrier gas flows through a second pressure regulator to the reference side of the thermal conductivity detector and from there to the sample injection systems. Two such systems are provided. One, a precision gas sampling valve, and the other, a liquid sampling device where samples are injected into the system by means of a hypodermic syringe. The sample is then carried into the column where the separation of components occurs. As each component arrives at the column exit, it flows through the sensing side of the thermal conductivity detector. The difference in thermal conductivity between the sensing and reference sides (which are part of a bridge circuit) produces an unbalanced voltage which is measured by a standard recorder.

The time required after injection for a given component to appear at the column exit is called retention time. By maintaining a constant flow rate, the retention time for a given component can be exactly reproduced on the recording paper.

After the detector, the flow passes through a three-way valve which in one position allows collection of each component, if desired, and in the other position provids measurement by a flow meter. With slow flow rates used (30-200 cc./min.) infrequent renewal of the carrier gas cylinder is required.

For detector construction, glass-coated thermistor beads are used. The carrier gas is supplied to the reference side by diffusion. Straight-through flow in the sensing side provides speed of measurement which is important for light gas analysis. The volume in the sensing side is minimized (approximately 0.25 cc) to provide maximum resolution of components. In the detector bridge circuit, a steady voltage, provided by dry cell batteries, is adjusted by a rheostat and measured by a voltmeter. A zero adjustment control and a precision step-wise range attenuation control are provided.

The precision gas sampling valve is mounted on the left-hand side of the cabinet (see Figure 2). Access to the column and detector chamber, which incorporates an air bath temperature controlled oven, is provided through a door on the left front. To the right front of the instrument are located an operating control. At the top is the temperature control system (20-225 C.), in the center the flowmeter, and the lower controls comprise the pressure regulator and gage, detector voltage control and voltmeter, recorder zero control, and precision stepwise recorder range control. This important control provides range adjustment in steps of ½ from 1 to $\frac{1}{128}$. The recorder is a strip chart recorder, 0-5 mv, with one second full scale response.

The silica gel column completely separated nitrogen, methane, ethane, carbon dioxide and propane in that order. The partition column produced single peaks for nitrogen-methane, ethane, carbon dioxide, propane, isobutane, normal butane, isopentane, and normal pentane respectively.

A 5 cc. sample was used to obtain sufficient peak height of the minor components for accurate measurement, and the range attenuator was used to keep the major components on scale.

A rough check, using the internal normalization method, provided an approximation of the composition of the mixture. From this data a synthetic mixture of known composition was run under similar conditions to obtain data for the plotting of the calibration curves shown in Figure 4. As an additional calibration, pure methane was run to provide a second calibration point for the methane analysis, as can be seen in Figure 2. To complete the analysis in the fastest possible time, the chromatograms for the unknown natural gas sample, the synthetic mix and the pure methane sample were intermixed in such a way as to avoid overlap of components in the silica gel column. This complete run took only 34 minutes. It should be noted that such intermixing does not affect the retention times or the

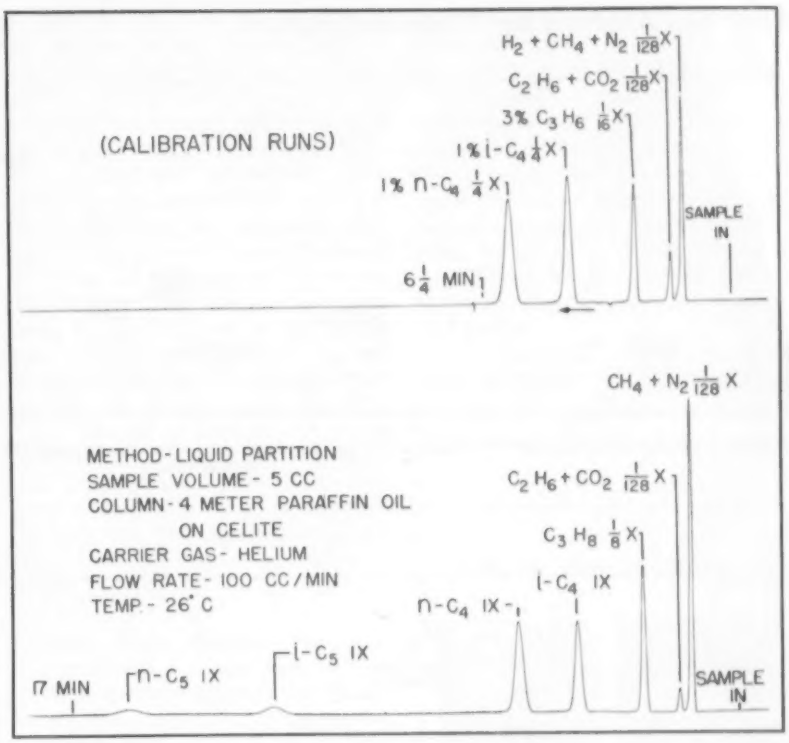

FIGURE 4—Natural gas analysis of heavy ends: Liquid partition column is used.

TABLE 1
Natural Gas Analysis

Component	MOL % Concentration By Mass Spectrometer	MOL % Concentration By Vapor Fractometry
Nitrogen	3.4	4.13
Helium	0.09	....
Carbon Dioxide	0.63	0.66
Methane	88.0	88.3
Ethane	4.8	4.7
Propane	1.7	1.76
n-Butane	0.27	0.21
i-Butane	0.21	0.17
n-Pentane	0.07	.04
i-Pentane		.03
Total	100.0	100.0

TABLE 2

Component	% Composition
N_2	21
CH_4	64
CO_2	2.5
C_2H_6	2.2
C_3H_8	0.5
CO	3.0
C_2H_4	0.2
H_2	Balance (6.6)

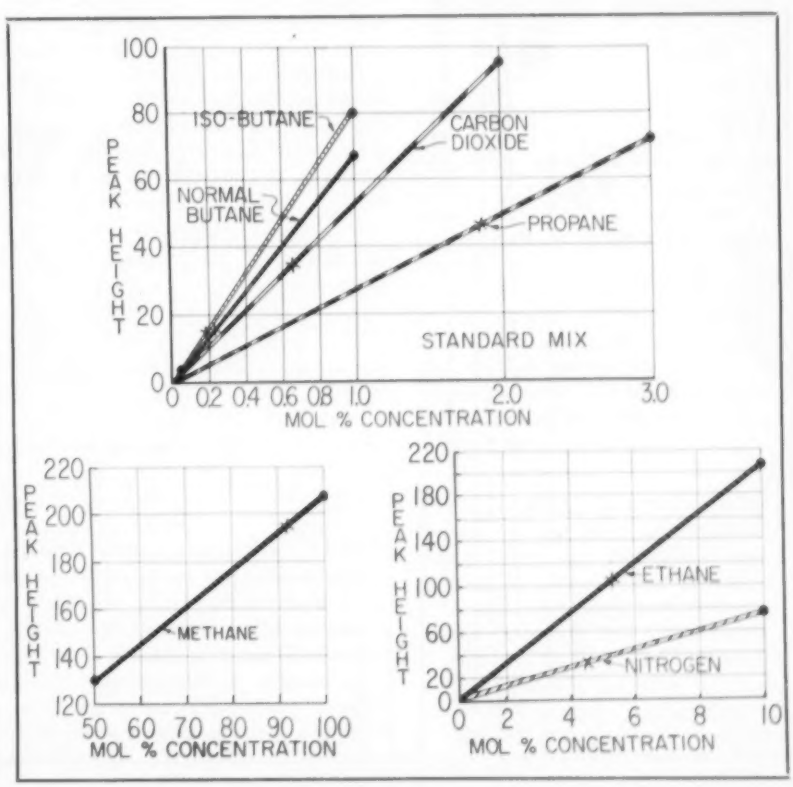

FIGURE 5—Calibration plots for natural gas analysis.

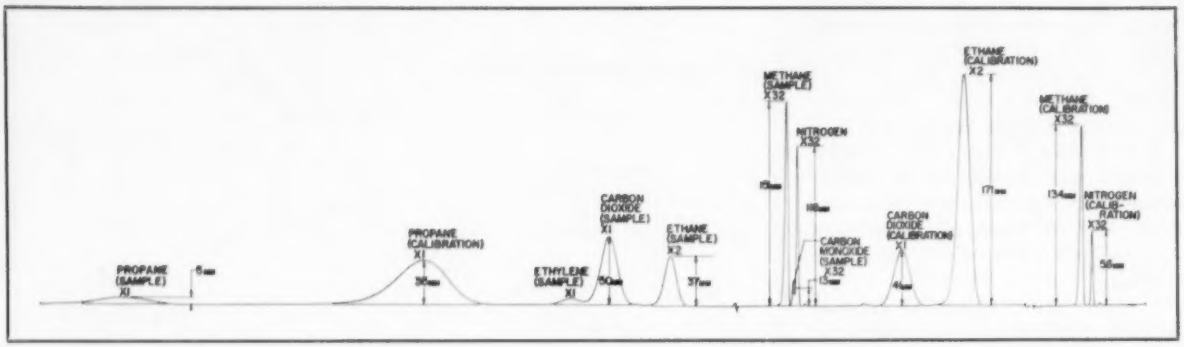

FIGURE 6—Manufactured gas sample: Treated in much the same manner as natural gases (25 C., 1cc sample, 2 meter silica gel column 100 cc/min flow).

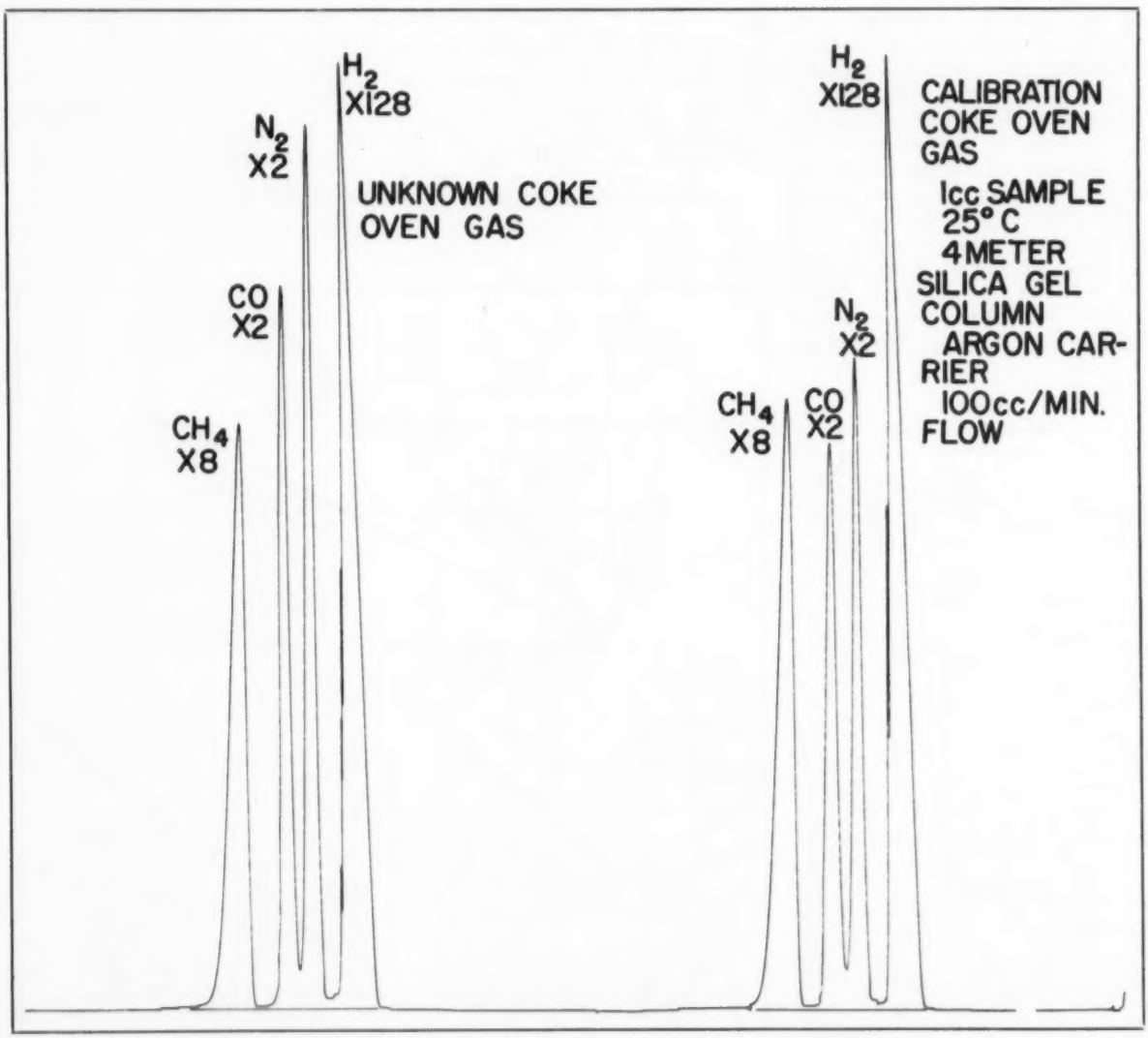

FIGURE 7—Coke oven gas sample: Run clearly shows the major components.

peak heights observed. Separate runs were made on the partition column of the natural gas sample, synthetic blend and pure methane. The analysis is given in Table 1. The pentanes were measured by correcting for half-band width then, using the same calibration curves plotted for the butanes.

It should also be noted that hydrogen, whose peak is in the downscale direction because its thermal conductivity is higher than helium, was included in the synthetic blend. Carbon monoxide was not included, although it is an important component in many fuel gases. Its position is shown by the dotted lines in Figure 2 (calibration runs). For satisfactory separation of this component, probably two 2-meter silica gel adsorbent columns should be used. Silica gel does not provide separation of oxygen and nitrogen; but adsorbents are available that will.

Manufactured Gases—Manufactured gases may be treated in much the same manner as natural gases. In fact some of these gases contain no components heavier than propane, thereby allowing the analysis to be made with a single determination on a silica gel column. Figure 5 shows a chromatogram of a sample of a manufactured gas supplied by a large Eastern distributor. The same calibrated mix used for the natural gas analysis has once again been intermixed during the run so that the bands of N_2, CH_4, C_2H_6, and CO_2 of the standard are followed by the corresponding bands of the sample. The bands of standard and sample propane appear at the end of the run as expected. The peak height ratios were used to determine concentration of these sample components.

It should be noted that two bands of the sample gas representing CO and C_2H_4 respectively, are not contained in the calibration mix. In standard practice the calibration mix for samples of this type would have been formulated to include these gases. In this case a separate run of a gas available in the laboratory and containing a known concentration of CO was run following the above determination, and the peak height ratio of the CO peak in this gas to that of the manufactured gas was used to determine the CO concentration of the manufactured gas. The small amount of ethylene was calculated by area comparison with area under the propane peak in the calibration mix. The final quantitative analysis of the manufactured gas based upon this method of analysis is shown in Table 2.

Coke Oven Gases—Coke oven gas represents a special case in that hydrogen is a major constituent. Since, unlike all other gases, hyrdogen has a higher thermal conductivity than helium, it will cause a negative peak response on the recorder when it appears in a mixture run with helium as a carrier gas. However, if argon is substituted for helium, the hydrogen peak as well as the peaks of all other gases will be in the same direction.

Figure 6 shows a chromatogram of a calibration mix followed by an actual coke oven gas, using argon as a carrier gas and silica gel as a column material. The run clearly shows the major components: hydrogen, nitrogen, carbon monoxide, and methane.

The analysis of these components is shown in Table 3 in order. The minor ingredients of the gas, such as propylene, acetylene, and butanes, amounting to less than 4 percent of the mixture, are not measurable on this column, but could have been detected on a partition column with helium carrier gas as previously demonstrated in Figure 3.

This presentation was condensed from the original paper delivered before the American Gas Association, Philadelphia, May 18, 1956.

TABLE 3

H_2	56.8%
N_2	5.4
CO	6.2
CH_4	28.1
Other	3.5

What is Gas Chromatography?

It's a method that consists of carrying a mixture through a column by means of a carrier gas. The different affinities of the components for the column packing (called the stationary phase) cause them to travel at different rates through the column. They arrive at the column exit separately where they are measured by a suitable detector. Recordings obtained by measuring the detector output result in a series of peaks in which the peak location or characteristic component speed provides the qualitative information. The peak heights or areas can be used for determining percent concentration.

Meet the Authors

Coates

Brenner

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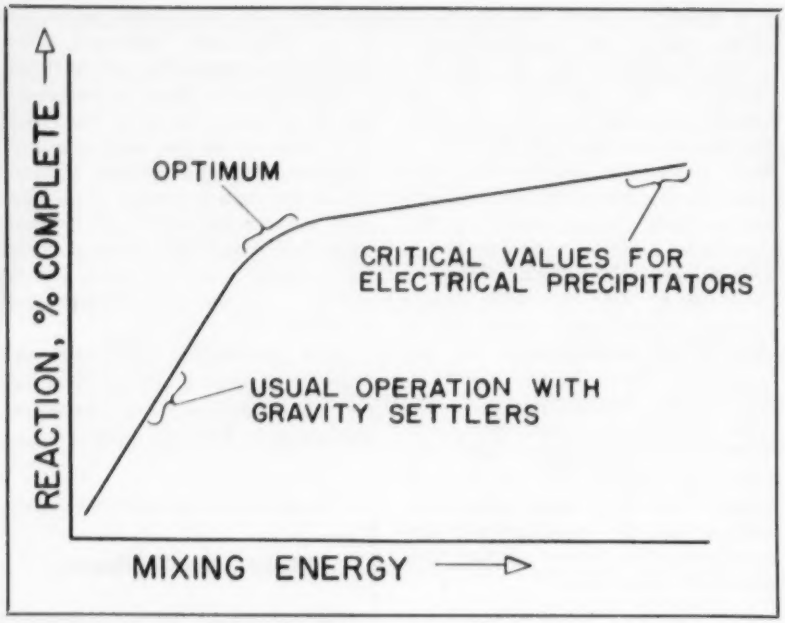

FIGURE 1—Optimum speed for the mixer: A significant addition of mixing energy can be imparted before coagulator is limited.

New Process for Removing Reformer Feed Stock Sulfur

Using acid-treating plus electrostatic mixing and coagulation, this process effects almost complete removal of sulfur in reformer feed stocks. Investment and operating costs are far less than hydrodesulfurization.

R. J. Phillips
Howe-Baker Corporation
Houston

HYDROGEN SULFIDE corrosion and catalyst contamination in catalytic reformers can be economically eliminated with only a modest investment for new equipment. A newly announced process-Electrostatic Desulfurization—combines the recently introduced techniques of electrostatic mixing and settling with the ancient chemistry of acid treating to effectively desulfurize reformer feed stocks. The process is economical to install, operate and maintain, averaging about one-fifth of the out of pocket costs for a comparable-sized hydro-desulfurization plant. Investment costs will approximate $20 per barrel, operating costs less than one cent per barrel, and maintenance costs are simply those required for routine annual inspection.

Process Flow Is Simple—The flow diagram (Figure 2) demonstrates the simplicity of the operation. Sulfuric acid is mixed with the untreated virgin naphtha feed and thoroughly intermixed in a high-speed propellor bladed mixer. The acid-oil mixture is introduced through the bottom of the first settling vessel into an electrostatic field created by the imposition of a high voltage direct current potential on electrodes suspended within the vessel. The acid particles within the electrical field are violently agitated and given a high degree of mobility. This movement of the acid particles is known as "electrostatic mixing" and is responsible in large part for the high efficiency of the reaction.

After becoming thus thoroughly mixed, the acid particles are subsequently electrically coalesced in the upper portion of the electrical field and settled rapidly to the bottom of the vessel where they are continuously removed and recirculated to the untreated feed. The treated and desulfurized feed stock is mixed with a small quantity of weak caustic to insure neutralization of any trace quantities of acid, and electrically coagulated in the second treating vessel. The caustic-washed product, containing less than one ppm of sodium may then go directly to the catalytic reforming unit without intermediate storage.

Sulfur Effectively Removed—Sulfur removal efficiencies are comparable with those obtained with hydro-desulfurization. Feed stocks with sulfur contents from 0.02 weight percent to as much as 1.2 percent have been exhaustively tested. The treated products had sulfur contents in the range 0.002 to 0.005 wt. percent (20 to 50 parts per million). By increasing the severity of the operation, or, in the case of very high sulfur content feed stocks, adding a second acid treating stage, virtually complete sulfur removal can be attained.

Electrostatic Mixing Increases

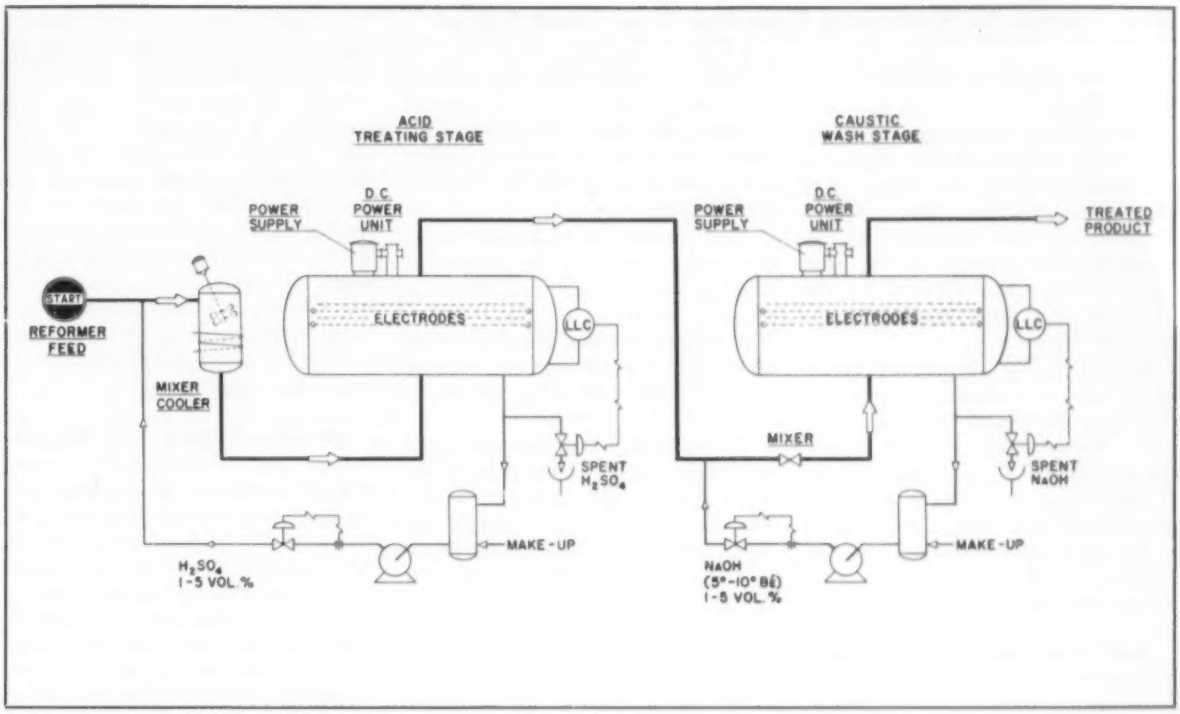

FIGURE 2—Flow scheme for process: Efficiency of reaction is due to electrostatic mixing.

Reaction Efficiency—The effectiveness of the new process is due in large part to the phenomena known as electrostatic mixing. Of course the chemistry of acid treating is well known. However the high product degradation and sludge losses associated with conventional batch or gravity settling apparatus have previously ruled out acid treating for consideration in this particular application. To a considerable degree, the product degradation previously experienced was due to such side reactions as esterification and sulfonation, provoked by the higher reaction temperatures employed. In the Electrostatic Desulfurization process, the necessity for these more severe operating conditions is obviated by electrostatic mixing. As noted briefly above, this type of mixing is brought about within the electrical field created inside the treater. The acid-oil mixture is vigorously pre-mixed with the propellor bladed mixer to reduce the particle size of the acid droplets. Then, as the droplets enter the electrical field in the bottom of the first treating stage, they are violently excited and given random movement. Thus the optimum opportunity for any given acid droplet to contact a specific sulfur molecule is provided. Because a significant quantity of the acid droplets will have been reduced to colloidal dimensions by the propellor mixer, the surface area of the acid particles moving within the vessel is enormous. A corresponding high reaction efficiency is effected.

Electrical Coagulation Eliminates Carryover—A highly necessary adjunct to the over-all effectiveness of the process is the employment of electrical coagulation to eliminate carryover of treating agent. The violent random movement described above plays an important role in the coagulation step. Sufficient electrical potential is imposed to statistically enhance the random probability of any two of the acid (or caustic) particles contacting each other. They will coagulate on contact. This is repeated until the particle size has grown to the point that an individual particle has sufficient mass to fall to the bottom of the vessel by gravity.

The carryover of acid will average less than 0.003 volume percent. This trace quantity is neutralized with weak caustic (usually 10° Baumé) in the second treating stage. The carryover of sodium from the second stage is warranted not to exceed one ppm. At the refiner's option, a water wash can be employed to virtually eliminate sodium carry-over.

Sludge Losses Are Low, Pumpability Good—The expensive product degradation associated with conventional acid treating is minimized in the Electrostatic Desulfurization process for several fundamental reasons. First, the contact time between oil and acid is sharply reduced. The effective contact time in the new process is less than 10 minutes, although the residence time of the oil in the process vessel will be slightly over twenty minutes. The acid concentration in the oil in the upper half of the vessel is very small.

Second, the reaction is carried out at ambient temperatures. Little difficulty is experienced with the unde-

sirable side reactions at temperatures below 160 F.

Third, the process is operated under a positive pressure; hence oxygen is totally excluded and the formation of the familiar gummy, high viscosity polymers is prevented. Thus the pumping characteristics of the acid are excellent, as evidenced by the fact that it is continuously recirculated until spent.

Since the acid (or caustic) layer within the vessel serves as a ground electrode, the separation of acid and oil is complete and there is no entrained oil in the acid phase. Since the older gravity-settling process usually had oil losses due to entrainment in the sludge of about 2 percent, the effectiveness of the electrical coagulation is readily apparent.

Acid Type and Consumption—The source and type of sulfuric acid is not particularly critical so long as the concentration is kept above 88 percent. The Electrostatic Desulfurization process has been quite effectively employed with spent alkylation acid, containing measurable quantities of both alkylate and polymer. The consumption will average the stoichiometric amount plus approximately 10 percent. Maximum utilization is obtained by recirculating the acid until the concentration falls below the minimum allowable.

Operating Variables and Labor Requirements—The operating variables requiring adjustment by plant operators are few. Looking again at the flow diagram the variables which can be controlled are as follows. The propellor bladed mixer ahead of the acid treating stage is provided with a variable speed motor drive and is about the only portion of the equipment that is adjusted by operators. The optimum speed of the mixer is established during the startup. Thereafter, the speed is increased or decreased as indicated by sulfur analyses of the treated product.

Additionally, the speed of the mixer can be briefly reduced in the event of an upset in the coagulator. Figure 1 illustrates diagrammatically that there is considerable latitude in the operation of the mixer. From the figure, it may be seen that there is a certain minimum level of mixing necessary to accomplish the desired reaction, and then a significant additional increment of mixing energy can be imparted before the coagulator is limited.

The quantity of acid and caustic recirculated are not important, as long as they exceed the minimum quantity required for the reaction. The designer usually selects a rate of about 2 to 5 percent of the oil rate to insure good control by the instruments.

The total electrical potential across the electrodes is controlled by a variac located on the instrument panel. The optimum potential (usually between 20-25,000 volts) is established by the startup engineer and there is no need for plant operators to change it.

The level of acid or caustic in the bottom of the treating vessels is automatically controlled but should be occasionally checked.

Once the unit has been put into operation, it is not necessary to provide full-time operating attention. About one hour per shift can be profitably utilized for sampling, recording instrument readings, etc., but there is no need for frequent adjustments. Therefore, the operation of the treaters can be added to the duties of the crews at either the feed preparation or reformer units without imposing a hardship.

Service Factors and Maintenance—Since the operating temperatures and pressures are low, and there are no moving parts in the equipment, mechanical failures are essentially nil. All electrical components are considerably over-designed (when considering their normal versus maximum load) and well protected with safety device. Maintenance, then, evolves to routine annual inspection during turnarounds of associated equipment.

Investment and Operating Costs—For the average installation, the total installed cost of the Electrostatic Desulfurization process will be approximately $20 per barrel of oil feed. Frequently, this amount can be substantially lowered by using existing vessels.

Operating costs will average less than 1 cent per barrel of oil, and can be reduced to an even lower figure if alkylation acid is available. Sodium hydroxide of any concentration can be used but concentrations between 5 and 10° Baumé are recommended. Electrical power costs are very small, since the normal operating load is 1 KVA per treating stage, or a total of 2 KVA for the two stages. Some additional expense is entailed for pumping costs, instrument air, and fractional operating labor.

Summary—In summation, it can be said that the process effectively reduces sulfur concentrations of virgin naphtha feed stocks to acceptable levels with these advantages: low initial investment, low operating costs, minimum product degradation, negligible carryover of treating agents, and simplicity of operation. # #

Meet the Author

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New Method for Vapor Pressure

For the hexanes-plus fraction of natural gasoline, this method is quicker and more accurate.

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Dallas

WHEN CALCULATING the vapor pressure of natural gasoline, you need to know the vapor pressure of each component in order to find the correct vapor pressure of the mixture.

Composition of the hexanes or heptanes and heavier fraction is unknown from the low temperature fractional analysis; thus, the vapor pressure of this fraction must be determined in some other way. Common practice is to determine the specific gravity and average molecular weight and, using these properties, make correlations to calculate the vapor pressure. This is a valid procedure as long as it is known that only paraffinic hydrocarbons are present. In many cases, however, aromatics and naphthenes are present which keep the molecular weight and specific gravity from correlating with vapor pressure. In this case it is necessary either to determine the vapor pressure of the hexanes plus fraction or be satisfied with a very inaccurate approximation.

Several methods are available for determining or calculating vapor pressure but most of them require considerable time and/or sample.[1, 2, 3, 4, 5] This article outlines a procedure whereby vapor pressures of hexane and heavier fractions may be obtained in thirty minutes using only one milliliter of sample. Results using pure compounds show an accuracy of from two to six percent.

Apparatus—The apparatus (Figure 1) is essentially the same as that used by Smith in his reanalysis of cut-points.[6] The apparatus is built in three parts, (1) a sample bulb where the sample is vaporized, (2) a differential manometer to equalize pressures and (3) a pressure measuring manometer.

The only other apparatus necessary is two small dewar flasks, a barometer, two good thermometers, one to measure temperature to ±0.1 F., a good vacuum pump, and liquid nitrogen.

Procedure—The chilled sample is transferred to the chilled small sample bulb by means of a hypodermic syringe, and the bulb is then connected to the manifold. A dewar flask containing liquid nitrogen is placed around the sample bulb in order to freeze the entire sample. The manifold and sample bulb are then evacuated. Air removal is complete after ten minutes evacuation.

The dewar flask is removed and the sample is allowed to come to room temperature. A dewar flask containing water at slightly above 100 F. is then placed around the sample bulb. The temperature of the water in the flask is allowed to adjust to 100 F. ±0.1 F. and the mercury level is adjusted in the differential manometer until the two legs are at the same height. This is done by applying either a pressure or a vacuum to the left leg of the pressure measuring manometer.

It is assumed that the vapor pressure of the sample will be equal to the absolute pressure in the sample bulb as read on the pressure manometer. This pressure is calculated by the following relation:

$$V.P. = \frac{Pb - Pm}{51.7116} \qquad (1)$$

where: V.P. = vapor pressure in pounds per square inch
Pm = corrected manometer reading in millimeters of mercury
Pb = corrected barometric pressure in millimeters of mercury

Experimental Work—Tests on pure compounds were made using Phillips pure grade[7] hexane, heptane, iso-octane and C.P. benzene, along with a mixture synthesized from the hexane, heptane and iso-octane. Table 1 shows the composition of the mixture.

TABLE 1
Composition of Synthesized Mixture

Component	Ml. Component	Liq. %	Mol. %	V.P. @ 100 °F.	Mol. Fr. V.P.
Hexane	5	76.93	79.54	4.956	3.942
Heptane	1	15.38	14.17	1.620	0.230
Iso Octane	0.5	7.69	6.29	1.708	0.107
			Calculated vapor press.		4.279

In each case the results obtained were lower than the true vapor pres-

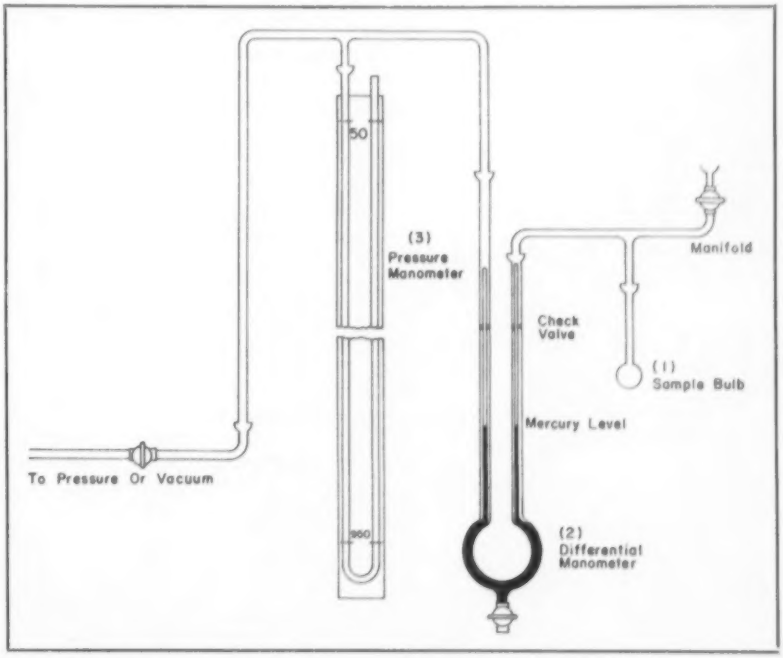

FIGURE 1—Apparatus for vapor pressure data: Only 30 ml of sample is required.

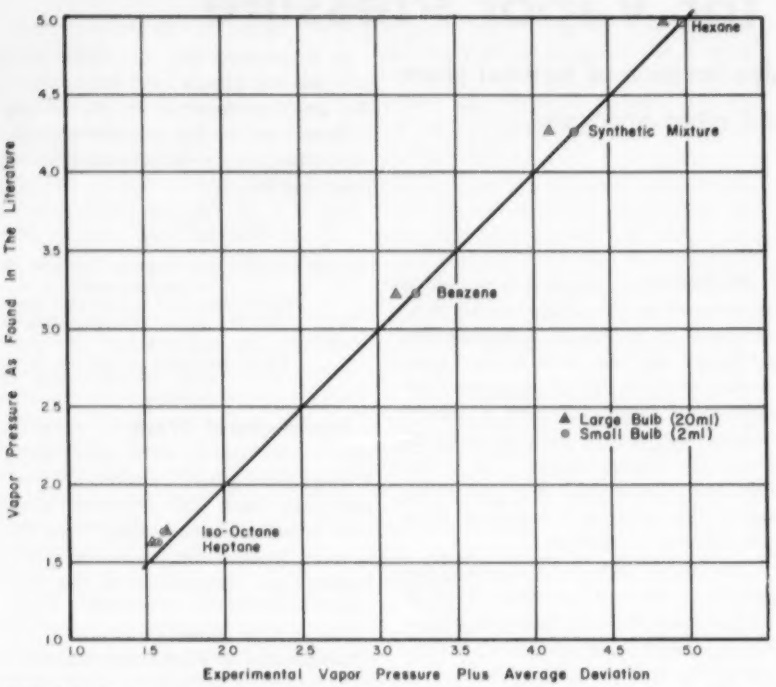

FIGURE 2—True versus experimental vapor pressure: A constant error indicated for large bulb.

sure values as reported in the literature. This seemed to indicate that the apparatus had a constant error. The presence of vapor above the liquid depletes the liquid of light components and thus lowers the vapor pressure. This error was calculated by subtracting the average deviation from theoretical values. Figure 2 is a plot of the theoretical vapor pressure as found in the literature vs. experimental vapor pressure plus the correction.

TABLE 2
Results of Runs Using the Large (20 ml.) Sample Bulb

Component	Mixture	Benzene	Hexane	Heptane	Iso-Octane
Left Leg Manometer, mm	800.9	828.2	773.8	877.0	872.5
Right Leg Manometer, mm	261.8	241.1	282.2	204.3	241.1
Difference, mm	539.1	587.1	491.6	672.7	587.1
Temperature of Manometer, °F	75.0	74.5	74.0	74.0	75.0
Correction Factor	0.99567	0.99572	0.99577	0.99577	0.99567
Corrected Manometer, mm	536.8	584.6	489.5	669.8	661.8
Corrected Barometer, mm	749.8	745.6	740.4	749.0	745.6
Barometer—Manometer (V.P. mm Hg)	213.0	161.0	250.9	79.2	83.8
V.P. psi (V.P. mm Hg/51.7116)	4.119	3.113	4.852	1.532	1.621
Theoretical Vapor Pressure*	4.279	3.224	4.956	1.620	1.708
Error, psi	—0.160	—0.111	—0.104	—0.088	—0.087
Percent Error	3.74	3.44	2.10	5.43	5.09

Average Deviation: 0.122 psi.
* The term "theoretical vapor pressure" refers to the vapor pressure found in the literature, and rounded off to the third decimal. **The Natural Gasoline Supply Mens' Association Data Book**, 1951, was the source of all factors.

TABLE 3
Results of Runs Using the Small (2 ml.) Sample Bulb

Component	Mixture	Benzene	Hexane	Heptane	Iso-Octane
Left Leg of Manometer, mm	796.0	829.2	775.8	873.5	871.2
Right Leg of Manometer, mm	264.0	240.2	281.0	206.0	208.5
Difference, mm	532.0	589.0	494.8	667.5	662.7
Temperature of Manometer, °F	76.0	76.5	77.0	77.0	77.5
Correction Factor	0.99557	0.99542	0.99547	0.99547	0.99544
Corrected Manometer, mm	529.6	586.3	492.6	664.5	659.7
Corrected Barometer, mm	749.6	749.0	746.7	744.4	743.2
Barometer—Manometer (V.P. mm Hg)	220.0	162.7	254.1	79.9	83.5
V.P. psi (V.P. mm Hg/51.7116)	4.254	3.246	4.914	1.546	1.615
Theoretical Vapor Pressure	4.279	3.224	4.956	1.620	1.708
Error, psi	—0.025	—0.078	—0.042	—0.084	—0.093
Percent Error	0.58	2.42	0.85	5.18	5.44

Average Deviation: 0.064 psi.

Two series of tests were run in order to determine which size bulb to use for the sample and to find out if the temperature of the manifold being different from that of the bath had any significant effect on the determination. It was found that the small 2-milliliter bulb gave an instrument constant error about one half that of the larger 20-milliliter bulb. This being the case the small bulb was then considered to be the better choice for all runs. From the results using the small bulb it is apparent the samples with vapor pressures near 4 pounds per square inch are the most accurate. (See under Mixtures and Hexanes in Table 3.)

A hot stream of air was played over the manifold in each of these runs and its temperature was adjusted to the same temperature as the bath. Results with and without this stream of hot air did not show any significant changes. It is probable, however, that if the temperature could be held constant throughout the apparatus that more accurate results could be obtained. An ideal way to do this would be to fabricate a double walled manifold which would act as a dewar or through which could be circulated air or water at the desired temperature, or to enclose the entire apparatus in a constant temperature case.

Table 2 contains the results of the series of runs using the large vaporization bulb, and Table 3 contains the results using the small vaporization bulb.

A number of gasoline samples which our laboratory received for analysis were checked in order to see how the calculated vapor pressure agreed with the Reid vapor pressure as reported by the plant. The Reid vapor pressure was converted to true vapor pressure using a natural gasoline vapor pressure chart found in the Natural Gasoline Supply Men's Data Book.[8] The error on samples which had a vapor pressure ranging from 30 to 34 psi ranged from —0.3 to + 1.0 psi. See Table 4 for a list of samples from one plant. Results on some tests not tabulated in Table 4 show that good correlation is not obtained on samples containing over one percent propane. Evidently the presence of light components causes the Reid vapor pressures to deviate materially from the values given in the table. The conversion of Reid vapor pressure to true vapor pressure by means of the fore

Meet the Author

J. C. WINFREY received his Masters degree in chemistry from East Texas State Teachers College in 1949. He spent a couple of years teaching high school chemistry, then moved to Eagle Picher Lead Company in Dallas as control chemist. From there he went to Lone Star Gas Company and worked in fractional analysis of special problems. It was while he was at Lone Star that Winfrey did the work on this article. At the present time he is a research chemist in the Chemical Engineering department of Dow Chemical Company, Freeport, Texas.

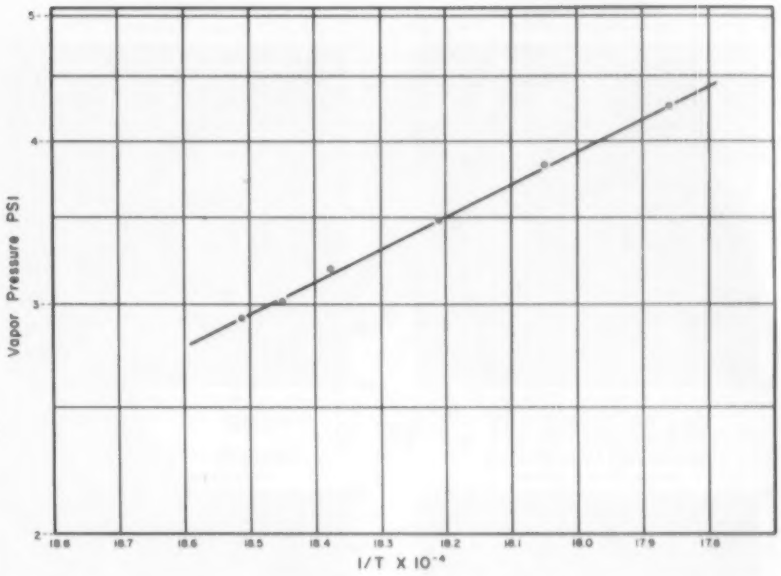

FIGURE 3—Plot of log vapor pressure versus reciprocal of absolute temperature: A straight line proves reliability.

mentioned chart is not the most desirable procedure, but accurate data was not available for this conversion.

In order to make a final check on the accuracy of the data, vapor pressures were determined on a number of samples at various temperatures. After the data was collected it was plotted as log vapor pressure vs. reciprocal of absolute temperature. Figure 3 shows this plot which is a straight line, thus proving the reliability of the procedure and data. Tables 5 and 6 contain the data from which Figure 3 was plotted.

The vapor pressure of the total sample may be determined in the same manner as the hexanes plus fraction except that lower temperatures must be used to hold the pressure within the range of the manometer; 32 F. was found to be quite satisfactory for samples containing little or no propane. A rough check of the accuracy of an analysis may be made by comparing the vapor pressure of a sample as determined in this manner against a calculated value derived from the analyzed composition and the vapor pressure of each component. The NGAA sample Number 7 was checked by this method. The vapor pressure at 32 F. was found to be 10.7 psi. The calculated vapor pressure from the analysis was found to be 10.7 psi. Values for the vapor pressure at 32 F. were taken from R. Vincent Smith's[9] vapor pressure chart. The largest error in this type of check is the vapor volume if an appreciable amount of light components is present.

TABLE 4

Calculated Vapor Pressure Compared To Actual Vapor Pressure As Determined By Reid Method

Reid V.P.	True V.P. From Chart	Calc. True V.P.*	Difference	Percent Propane
34.0	34.7	34.97	+0.27	0.00
32.5	33.5	35.12	+1.07	0.00
30.0	31.7	31.77	+0.07	1.47
31.2	33.2	33.38	+0.18	0.00

* Calculated from Pod analysis and hexanes plus vapor pressure by this method.

ACKNOWLEDGMENT

The author wishes to acknowledge the critical examination and suggestions for this paper given by H. W. Black, without whose help and suggestions, completion of this paper would have been impossible.

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[6] From a paper originally presented at NGAA Low Temperature Fractional Analysis Seminar, March 15-16, 1951, at the Texas Hotel, Fort Worth, Texas, by D. E. Smith, Phillips Petroleum Company, Bartlesville, Oklahoma.

[7] Phillips 66 Hydrocarbons—Pure Grade 99 Mol. % Minimum.

[8] Vapor Pressures vs. Temperatures for Motor and Natural Gasolines, Natural Gasoline Supply Mens' Association Data Book.

[9] Smith, R. Vincent, PETROLEUM REFINER—22, No. 1, 79-81 (January, 1943).

TABLE 5

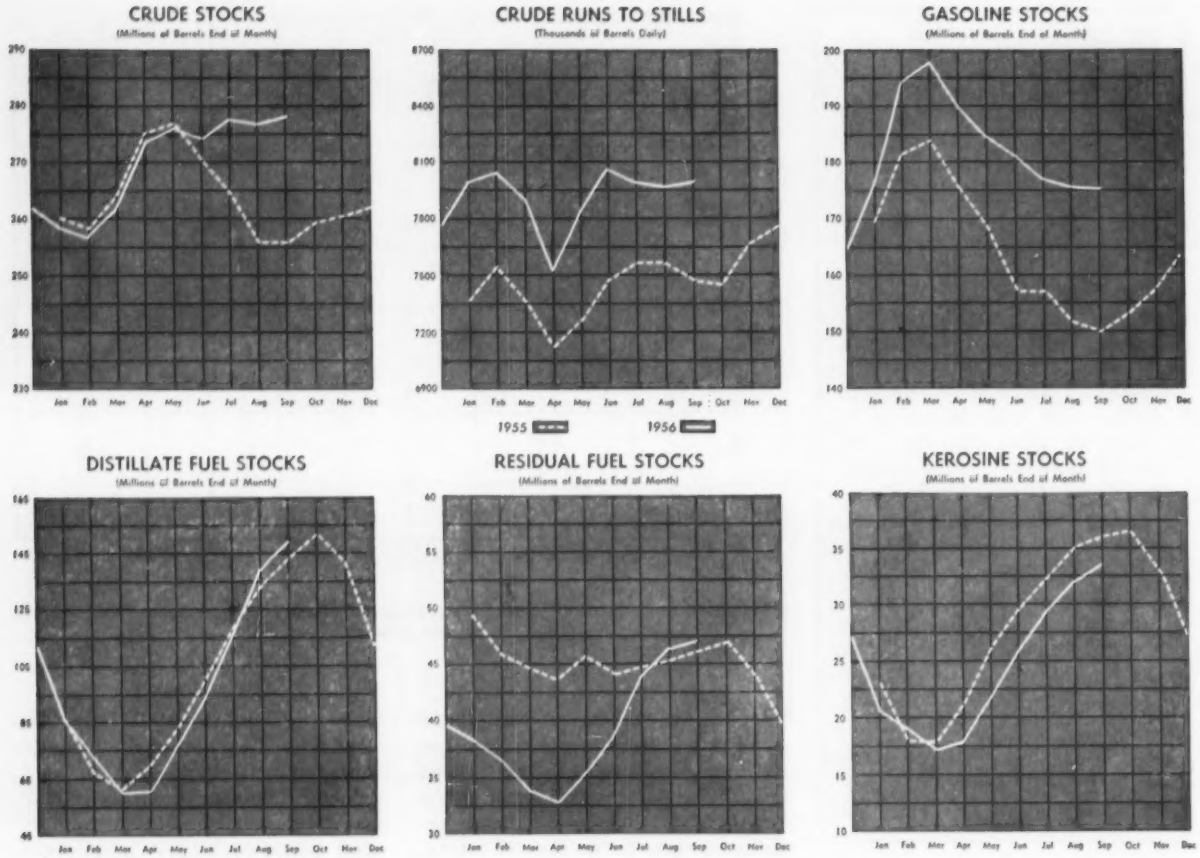
Data for Vapor Pressures at Various Temperatures of the Mixture

Run Number	1	2	3	4	5	6
Temperature, F	80	82	84	89	94	100
Left Leg of Manometer, mm	831.8	826.8	824.4	814.0	804.0	796.0
Right Leg of Manometer, mm	238.0	242.0	247.0	251.2	259.8	264.0
Difference, mm	593.8	584.8	577.4	562.8	544.2	532.0
Temperature of Manometer, °F	75.7	75.5	77.0	77.5	78.0	76.0
Correction	0.99552	0.99552	0.99547	0.99532	0.99538	0.99557
Corrected Manometer, mm	591.0	582.3	574.8	560.2	541.7	529.6
Corrected Barometer, mm	742.0	742.0	740.6	740.6	740.6	749.6
Barometer—Manometer (V. P. mm Hg)	151.0	159.7	165.8	180.4	198.9	220.0
V. P. psi (V.P. mm Hg/51.7116)	2.92	3.09	3.21	3.49	3.85	4.254

TABLE 6

Tabulation of Plot for Figure 3

Temperature, °F.	Temperature, °K.	1/°K	Vapor Pressure
80	540	0.001852	2.92
82	542	0.001845	3.09
84	544	0.001838	3.21
89	549	0.001821	3.49
94	554	0.001805	3.85
100	560	0.001786	4.254


CRUDE STOCKS
(Millions of Barrels End of Month)
CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)
GASOLINE STOCKS
(Millions of Barrels End of Month)
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)
RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)
KEROSINE STOCKS
(Millions of Barrels End of Month)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1955
1956

Taking Stock

Cecil W. Smith
Economics Editor

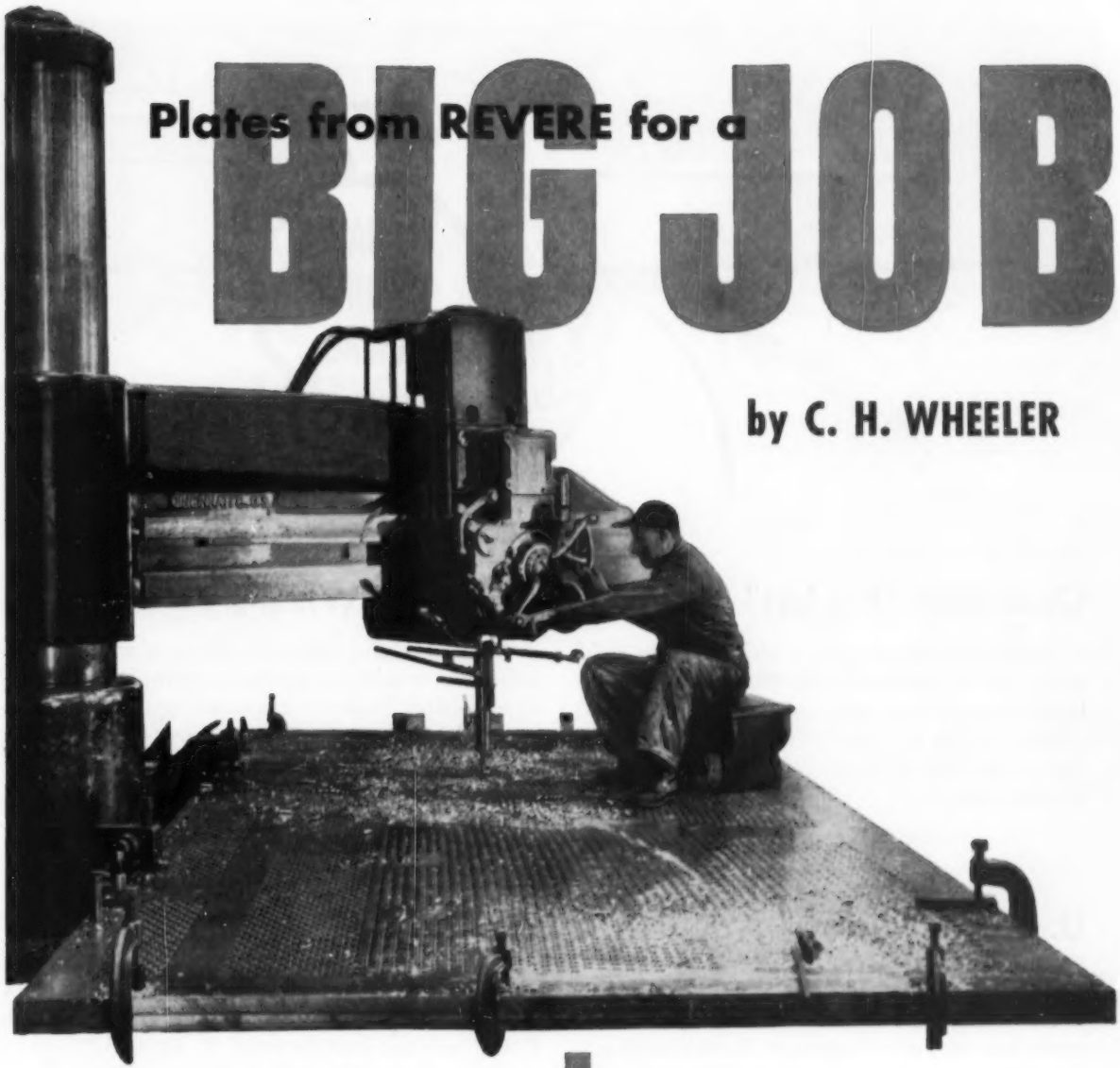
- Refining rate upped slightly
- Gasoline stocks easing slowly
- Distillate stocks gaining well

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1954:													
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,105	7,987	277,166	3,953	175,625	314	32,443	1,832	139,060	1,123	46,842	992	1,353
September	7,046	8,001	278,415	3,920	175,268	331	33,571	1,822	149,751	1,102	47,413	1,017	1,421
Week Ended:													
10-19-56	6,997	7,530	281,557	3,665	173,087	396	33,564	1,711	155,288	1,106	47,715	1,147	1,548
10-21-55	6,753	7,477	257,030	3,726	151,536	322	36,844	1,545	149,886	1,102	46,641	849	1,194

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Plates from REVERE for a BIG JOB

by C. H. WHEELER



Here you see two rolled Muntz Metal condenser plates, being drilled simultaneously in the plant of the C. H. Wheeler Manufacturing Co., Philadelphia 32, Pa. The plates were supplied by Revere. They measure 100-¾" x 203-¾" x 1-½" thick. Four plates were supplied for a Wheeler 2-pass divided water box unit having 95,000 sq. ft. of condensing surface. The overall length of the condenser, including water boxes, is 48 ft., and overall height, including steam dome and hot well is 34 ft.

Revere is an important supplier of plates and tubes for condensers, heat exchangers, and similar equipment, shipping to all parts of the country. Collaboration on alloy selection and specification is freely available. Just get in touch with the nearest Revere Sales Office.

COPPER ★ BRASS 1801 ★ REVERE ★ ALUMINUM

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere

For more data on advertised products, use Readers' Service Cards, last page.

Operation "Big Lift"

Here's how some quick thinking by field crews saved Standard Oil Company of California much time and expense. Read in the "How To Do It" section how two work over rigs were used to successfully lift a 62-ton distillation tower.

Keep Going to Page 214

U. S. "Know-How" Crosses Ocean

U. S. ethylene technology ventures to Europe due to Farbenfabriken Bayer's contract to build an ethylene oxide plant in Germany using the direct air oxidation method. For more details on this interesting feature item plus other construction reports from all over the world, read "Who's Building."

Keep Going to Page 222

"Catalysis"

Edited by Paul A. Emmett, this fourth volume in a series is devoted entirely to the Fischer-Tropsch synthesis, and should be of particular interest to the petroleum industry. Read about this book and others, some of which may be obtained at little or no cost, in "Reviewing New Books."

Keep Going to Page 212

Electronic Wizardry

Designers have turned to automation and are using electronic computers to complete plant designs and conserve engineering manpower. For an interesting article on how these computers are being used, plus a complete coverage on what's going on, when and where, read "What's Happening in the Industry."

Keep Going to Page 265

Men Among Men

John B. Armstrong and Harvey Menard received CNGA awards for 1956; Dr. Warren Lewis was the first lecturer at Texas University's E. P. Schoh Lecture Series; and T. P. Turchan has been appointed assistant general manager, Industrial Chemicals division, American Cyanamid Company. These are just a few of the refining-natural gasoline-petrochemical men mentioned in "What's Happening Among Men In the Industry." For the names of others . . .

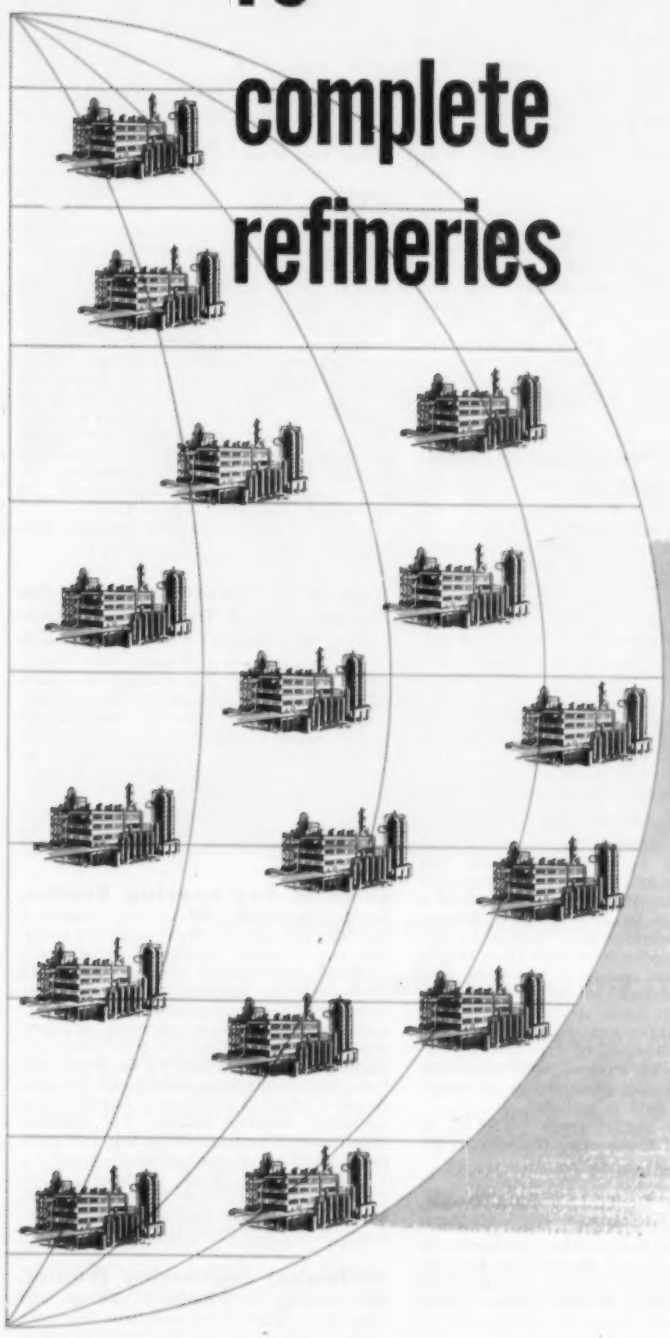
Keep Going to Page 277

Pocket Size

Read the description and see a comparative picture of the world's smallest circular slide rule. This and more than 30 other new items discussed in "What's New in Equipment and Manufacturer's Literature."

Keep Going to Page 326

16 complete refineries



1945

1. Refinery for B. P. M. at Cardon, Venezuela.
2. Refinery for Koppartrans Oljeaktiebolag at Gothenburg, Sweden.
3. Refinery for Venezuela Gulf Refining Company at Puerto La Cruz, Venezuela.
4. Refinery for Societe Generale des Huiles de Petrole at Dunkirk, France.
5. "Portable" refinery for U. S. Navy Department.
6. Lube oil refinery for Cit-Con Oil Corporation at Lake Charles, Louisiana.
7. Refinery for International Refineries Inc. at Wrenshall, Minnesota.
8. Refinery for Vacuum Oil Company Ltd. at Coryton, England.
9. Refinery for Burmah-Shell Oil Company at Bombay, India.
10. Refinery for Standard-Vacuum Oil Company at Bombay, India.
11. Refinery for Standard Oil Company (Indiana) at Mandan, North Dakota.
12. Refinery for Suntide Refining Company at Corpus Christi, Texas.
13. Refinery for Commonwealth Refining Company at Ponce, Puerto Rico.
14. Refinery for Esso Standard Oil Company at Antwerp, Belgium.
15. Refinery for Caltex at Visakhapatnam, India.
16. Refinery for Neste Oy at Turku, Finland.

1955

In the past 10 years alone, Lummus has completed or is currently working on 16 complete refineries. Combined, they represent a large percentage of the refinery capacity constructed in the last decade.

But complete refineries are only part of the Lummus story. Separate units for any and all phases of refining from distillation to petrochemical production have been designed, engineered and built by Lummus — as additions to existing installations or as integral parts of new construction.

In the past 50 years, Lummus has added over 700 petroleum and chemical plants and installations to the world's total. Think of Lummus when planning your next project.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y. *Engineering & Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

Reviewing New Books . . .

Catalysis, Vol. 4: Hydrocarbon Synthesis, Hydrogen and Cyclization, edited by **Paul H. Emmett.** The first two volumes in this series cover all of the general approaches and tools used to gain a better understanding of both homogeneous and heterogeneous catalysis. Volume three summarizes existing knowledge on the subjects of hydrogenation and dehydrogenation.

This, the fourth volume, will be of particular interest to the petroleum industry. Devoted entirely to the Fischer-Tropsch synthesis, it considers such important topics as the hydrogenation of carbon monoxide and related reactions, methanation, catalytic hydrogenation of coal and tar, and catalytic cyclization and aromatization of hydrocarbons.

Subsequent volumes, now in preparation, will cover in full detail, the mechanics of reduction by hydrogen, oxidation, hydration, dehydration, halogenation, isomerization, alkylation, polymerization, cracking, decomposition, and many miscellaneous reactions.

(Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y. 570 pages, $12.50. For sale by Gulf Publishing Company, P. O. Box 2608, Houston.)

Handbook of Chemistry and Physics contains more than 100 pages of new and revised technical information, and is therefore a handy reference source for interpretation of factual data.

One hundred and ninety outstanding chemists, physicists and mathematicians have prepared this 38th Edition. Material included is data on the three newest elements: Physical and Chemical Constants of the Rare Earth; Heat Formations of Inorganic Oxides; and Standard Calibration Tables for Thermocouples.

(The Chemical Rubber Company, 2310 Superior Ave., Cleveland, Ohio, $12.00.)

"Red Lead Technical Letter No. 11—Recommended Surface Preparation of Steel for Red Lead Paints" deals with surface preparation of steel prior to the application of primer paints.

It contains a handy quick reference table indicating the recommended surface preparation methods for specific types of steel structures, red lead primers, exposure conditions and drying times.

(Lead Industries Association, 60 East 42nd Street, New York 17, N. Y., no charge.)

Micro Lubricant Test Method, Viscosity-Neutralization Number, by **J. B. Christian, V. A. Lauer, A. L. Miller,** and **H. M. Schiefer,** Wright Air Development Center, U. S. Air Force. A study was initiated to develop miniaturized tests for petroleum, petroleum products, and related materials, samples of which are sometimes received by analytical laboratories in insufficient quantity for evaluation. This report, the first of a series, describes procedures for determining neutralization number and viscosity and their correlation with macro tests. The small-scale techniques are said to be as effective in purpose as their full-scale counterparts.

(Order PB 121355 from OTS, U. S. Department of Commerce, Washington 25, D. C., 19 pages, 50 cents.)

Chemical Process Industries, by **R. Norris Shreve,** consulting chemical engineer, and professor of chemical engineering, Purdue University. This book presents, in one volume, the modern methods used in the manufacture of chemicals and chemical products—broken down into unit processes and operations by convenient flow sheets. Such important factors as data on chemical and physical changes and reactions, economic statistics and costs, energy and power required, etc., are covered. Where figures were available, quantities of materials required to produce the finished product are given.

Wide in scope, the book covers the manufacture of chemicals themselves, and includes full description of many manufacturing industries based on important chemical changes, such as the making of plastics, synthetic fibers, ceramics, paints, explosives, and pesticides.

(McGraw-Hill Book Company, Inc., 330 West 42 St., New York 36, N. Y., 1004 pages, $11.50.)

Corrosion Preventative Additives. M. Feinleib and H. T. Francis, Armour Research Foundation for Wright Air Development Center, U. S. Air Force. Certain fractions of petroleum sulfonates used as inhibitors in instrument oils were identified as causing corrosion where the oils were used as ball bearing preservatives. The report describes a reproducible test developed to determine corrosion preventative characteristics of oils used with bearings with brass-to-steel and all-steel contacts.

(Order PB 121072 from OTS, U. S. Department of Commerce, Washington 25, D. C., 22 pages, 75 cents.)

An Electrical Conductance Test Method for Measuring Corrosion. D. Roller, Wright Air Development Center, U. S. Air Force. It was found that both in theory and in practice, determination of the rate of uniform corrosion of a metal specimen by measuring the change in electrical conductance has many advantages over older methods such as weight loss, gasometric or visual processes. The report enumerates advantages of the method and its limits of applicability, and describes measurement equipment and specimens, techniques of experimental design, methods of analysis, and tests conducted during the research. A literature survey of the field is included.

(Order PB 121089 from OTS, U. S. Department of Commerce, Washington 25, D. C., 34 pages, $1.00.)

The Fluid Agitation Handbook, covers in detail theoretical and practical approaches to fluid mixing problems. It outlines step-by-step procedures for determining optimum mixing characteristics of fluids in relation to their physical properties. Methods are given for scaling-up a laboratory mixing operation to a production process.

Chemineer, Inc. is making this book available at cost. Book contains numerous charts, diagrams, and photographs, and much of the material has not appeared in print before. A 46 item bibliography is provided.

(Chemineer, Inc., 1044 East First Street, Dayton 2, Ohio, 46 pages, $1.50.)

Techniques of Plant Maintenance & Engineering—1956. The book reports proceedings of the conference held with the Plant Maintenance & Engineernig Show and contains the texts of 16 papers, summaries of 15 roundtable discussions and answers to approximately 1100 specific questions.

"Reports from the maintenance field indicate the growing influence of the maintenance manager in top management councils when new plants are designed, when equipment purchases are contemplated, when new production layouts are under way. Inevitably, too, his influence must increase still more as plants adopt automation, and excessive downtime becomes a luxury no plant can afford," the editors state.

Industries receiving special attention include chemical plants and petroleum refineries. Subjects include preventive maintenance, getting maintenance people to work as a team, measuring the effectiveness of maintenance, sanitation, equipment replacement policies, independent contractors, 24-hour operation, painting, design and operation of maintenance shops, cost control, inspection procedures, building and yard structure maintenance, use of punched cards, electrical equipment, lubrication, machine tools, report writing, relationship between maintenance and purchasing departments, utilities, forms and reports, and tool room control.

(Clapp & Poliak, Inc., 341 Madison Avenue, New York 17, 248 pages. $10.)

Theoretical Investigation of the Mechanisms of Transfer of Materials Through Polyethylene, by **H. A. Bent** and **J. Pinsky.** This report, prepared for the Air Force, establishes equations for permeability of polyethylene, along with master plots for interpolating homologous materials and extrapolating for temperature changes. A bibliography is included for permeability, solubility and diffusion in polymer systems.

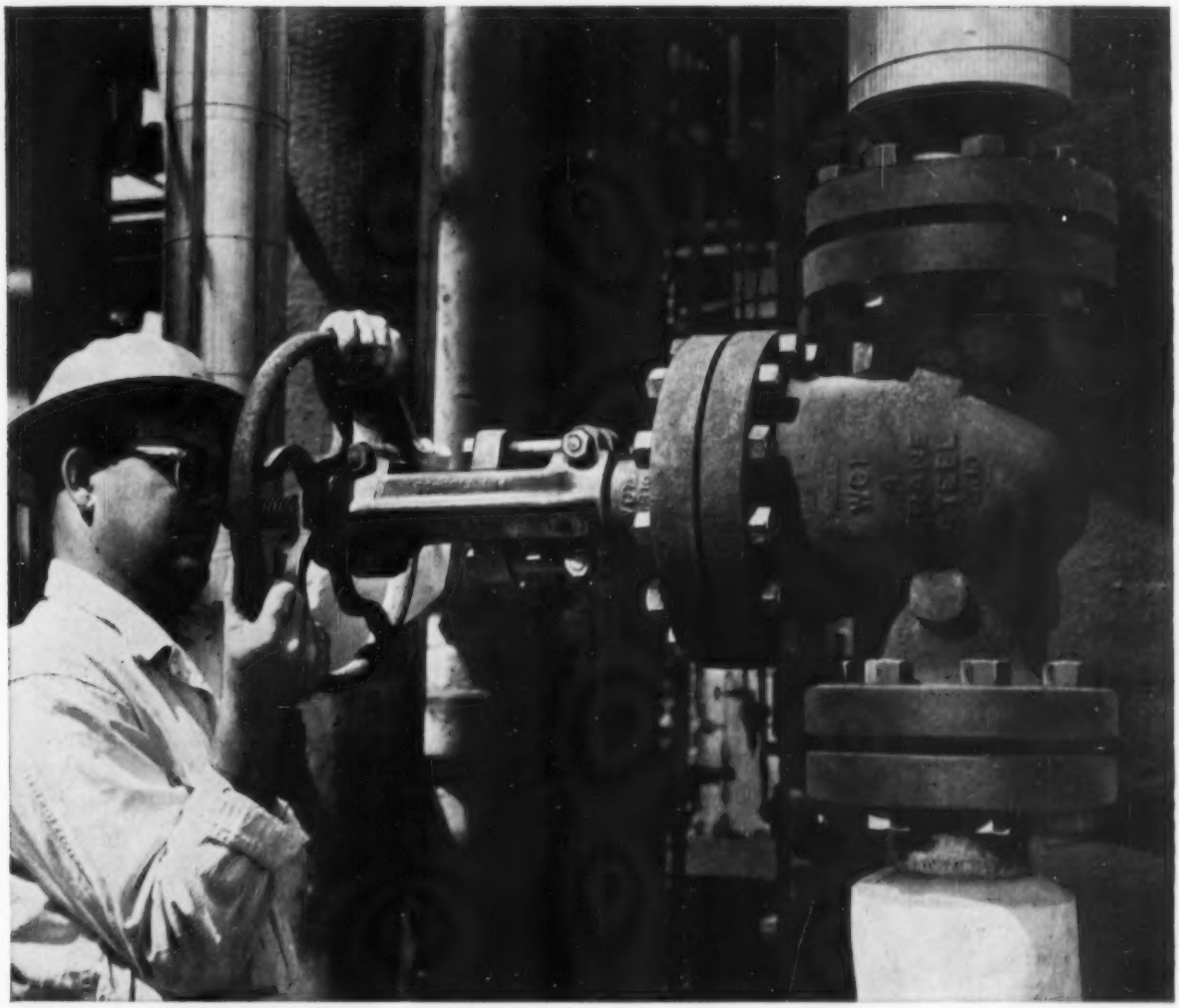
(Office of Technical Services, Commerce Department, Washington 25, 93 pages, $2.50.)

Chemical Engineering Kinetics, by **J. M. Smith.** To design, construct, operate, and improve equipment for carrying out chemical processes requires a knowledge of applied kinetics. This book emphasizes the engineering problems encountered in designing and operating reaction equipment. New advances are presented in interpreting catalytic reactions, particularly those occurring on solid catalysts. The important problem of diffusion in pores of solid catalysts is handled in a simplified, detailed fashion. The relationship between surface absorption and catalytic reactions is considered in detail.

(McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., $8.00. For sale by Gulf Publishing Company, P. O. Box 2608, Houston.)

Mechanical Engineering Practice, fifth edition, by **Charles F. Shoop,** and **George L. Tuve** is an excellent reference book for the practicing engineer. Measurement of technical and economic performance of machines and equipment is presented as a major engineering assignment, and attention is called to the precise requirements of the codes and standards sponsored by various professional groups.

(McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y., 471 pages, $7.00.)



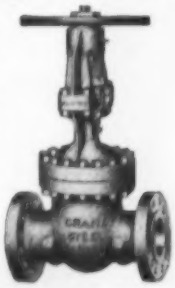
Two years on high-pressure hydrogen . . . no leakage . . . no maintenance!

Two years ago, Celanese Corp. installed this Crane valve in their large petrochemical plant in Bishop, Texas. It's a 4-inch No. 76XR 600-pound steel gate valve, on a line to a hydrogenation reactor. Pressure is 800 psi. and temperature 375° F.

What's the maintenance cost story on this valve—after 2 years of such severe service? *It hasn't cost a dime.* Celanese maintenance crews haven't been near it once with a wrench. Leakage? *Zero*—there hasn't been a trace of leakage during the 2 years the valve has been on the line.

Outstanding? Not for Crane valves. You'll find Crane valve performance records like this in chemical plants everywhere, and throughout industry. Crane's strictly quality design, materials, assembly and testing assure you of such dependable and low cost flow control service.

You'll find everything you need in valves and fittings in the complete Crane line. Get full information from your local Crane Representative, or write to the address below.



CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

For more data on advertised products, use Readers' Service Cards, last page.

How To Do It . . .

For a Saving of $20,000 . . .

Two Workover Rigs Lift A Large Tower

Here's the way Standard Oil Company of California field crews solved a difficult problem.

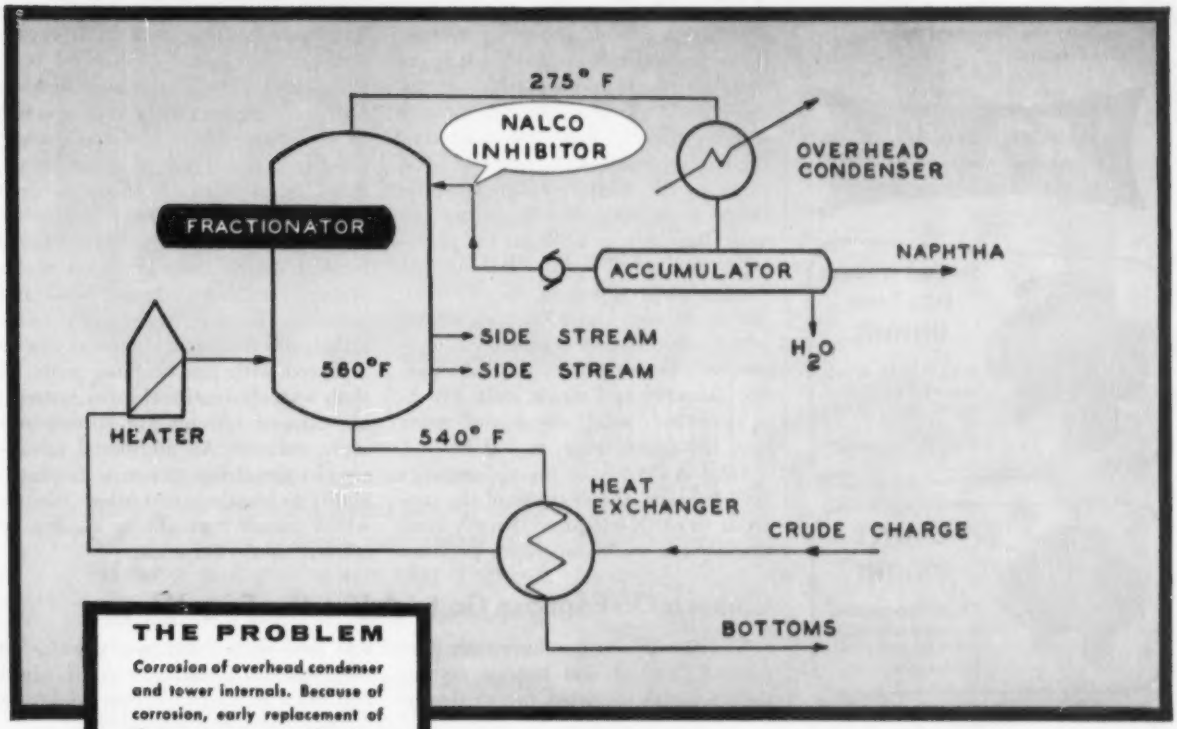
Early this year, men over-seeing construction of the crude unit for a new asphalt refinery near Maracaibo, Venezuela, were faced with a problem of lifting a 62-ton distillation tower into place. The contractor had adequate equipment, but it was in the United States, and moving it would cost approximately $20,000. A local check on facilities failed to turn up a substitute. Then, field crews, hearing about the problem, suggested the use of two "workover" rigs. These portable hoisting rigs used for lifting and lowering well pumps, rods and casing in nearby Boscan field appeared to have possibilities. A schedule was worked out to coordinate with oil field requirements. The engineers devised satisfactory guying, reinforcing, and top "marriage" struts to assure aligment of the masts. The substitute worked ideally and saved thousands of dollars. The photograph shows the start of the "big lift" which is progressing as easily as though specialized equipment had been used. Photograph courtesy of *The Standard Oiler*.

Airless Paint Spraying

In contrast to conventional sprayers, which use compressed air as an atomizing force, the new technique uses pressures of 500-600 psi and temperatures of 160-180 F. to hold solvents near the boiling point. When solvents in paints and lacquers are released to the atmosphere, they atomize instantly. The airless spray system, through minimizing overspray, is reported to reduce the required amount of coating material by as much as fifty percent.

Because of the high temperatures and pressures involved, 50 psi is considered high for conventional equipment. Thus, an important design consideration was the hose used to carry hot, pressurized solvents from heating system to spray gun. The hose assembly consists of a specially

HOW *Nalco* INHIBITORS CUT DOWNTIME 74% ... AND SAVED THIS FRACTIONATING TOWER



THE PROBLEM

Corrosion of overhead condenser and tower internals. Because of corrosion, early replacement of the tower was contemplated.

THE TREATMENT

Nalco Corrosion and Fouling Inhibitor applied into overhead reflux.

THE RESULT

In this case only one point of application protected both fractionator and overhead equipment. Iron in accumulator water brought below 0.5 ppm as compared to previous 100-150 ppm. Corrosion and plugging stopped, tower saved, and downtime for cleaning reduced by 74%.

EFFECTIVE Nalco corrosion control is very low-cost protection. For example, this refinery not only avoided the cost of a new tower, but cleaner tower internals actually resulted in better fractionation and higher quality products. If you would like further facts on Nalco Corrosion and Fouling Inhibitors, ask your Nalco Representative or write direct.

NATIONAL ALUMINATE CORPORATION

6259 West 66th Place • Chicago 38, Illinois
Telephone: POrtsmouth 7-7240
CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: Nalco Italiana, S.p.A.
WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

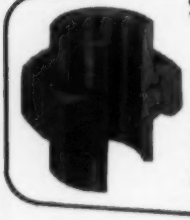
THE *Nalco*® SYSTEM ... SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

For more data on advertised products, use Readers' Service Cards, last page.

Catawissa
PERFECT SEAL
Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
FOR ALL TEMPERATURES!



Standard & Double Extra Heavy
UNIONS
Available with screwed or socket weld ends. 3000-lb. sizes 1/8" to 3"; 6000-lb. sizes 1/8" to 2".

ORIFICE UNIONS
With screwed or socket weld ends. 3000-lb. and 6000-lb. service.

MALE & FEMALE UNIONS
With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.

Standard & Double Extra Heavy
LUG NUT UNIONS
Hammer-type for quick opening and quick closing.

WRITE FOR CATALOG 56
showing the complete Catawissa line of Perfect Seal Products

CATAWISSA VALVE AND FITTINGS COMPANY
25 Mill Street • CATAWISSA, PA.

How to Do It . . .

compounded and extruded resin tube equipped with stainless steel jacket and three-piece steel couplings. The tube, which is inert to solvents in paint and lacquers, is tested for temperatures to 500 F. and pressures to 3000 psi. The stainless steel jacket resists fatigue and provides a positive blow-off proof anchor for the couplings.

The airless spraying system consists of a piston pumping system, paint heating system, hose and spray gun, integrated into a portable, three-part unit. A high pressure pump siphons material from the paint container and sends it at selected pressures to the heater. Fluid pressures range from 300 psi for coating oils and lubricants to 1200 psi for plastisols; most paints require 500-600 psi. At generated pressure the material passes through the 4000 watt heater which elevates and controls the temperature to any predetermined value. For lacquers and vinyls, only 140 F. is necessary; solid waxes and resins may require as much as 300 F.

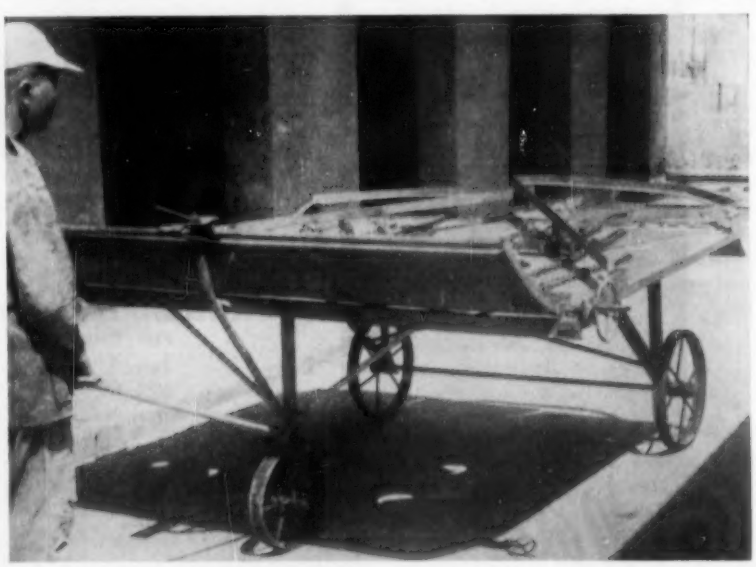
Heat is the key to the airless process—it lowers the viscosity of the material to easily-atomized, watery consistency and builds up vapor pressure to bring solvents to a boiling point. Heated material, circulated at a rate faster than rate of use, assures a constant supply of hot material to the spray gun.

Materials at the gun are released through a selected nozzle, usually manufactured of synthetic sapphire or tungsten carbide, which provides the required flow rate and spray angle. The gun may be located as much as 100 feet from the pumping system, using one quarter inch internal diameter hose as a flexible connection.

An advantage of the high temperature airless system is minimization of overspray; because of the absence of compressed air as an atomizer, there is no rebound of paint, even when spraying into trapped areas. Paint particles, conventionally chilled by air blast, hit the surface hot in this system, resulting in better bond and adhesion. Because overspray is minimized, the same film thickness can be achieved with less finishing material than with conventional spray systems; air exhaust systems are correspondingly reduced. An additional advantage of the airless system is its adaptability to plastisols and other coatings which cannot normally be applied by conventional equipment.

Chinese On Formosa Go to A Fire the Easy Way

The Kaohsiung refinery on Formosa (Taiwan) had trouble getting their foamite insulated fire shields to the fires with only two wheels. So they made a detachable front wheel and delta beam frame that could get



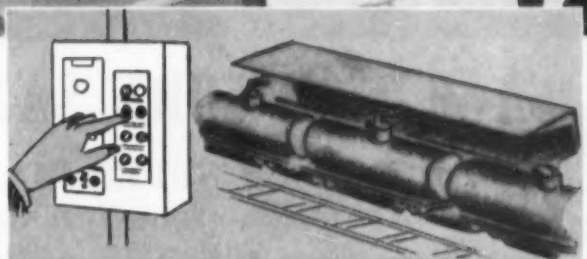
Added front wheel makes hauling simpler.

HANDLE YOUR PRODUCT FASTER...at less cost

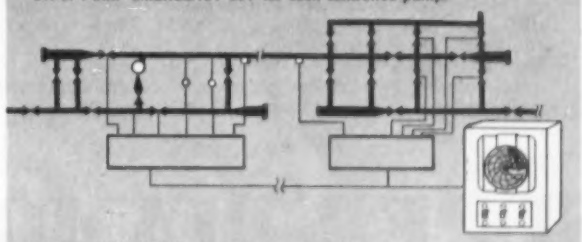
Sparton Control Systems now offer greatest opportunity yet for streamlining product handling—at the well field, refinery, processing plant, storage depot, distribution point or across open miles of pipeline.

They combine a variety of control techniques—all time-proven through years of communication use—into custom-tailored systems containing standard plug-in modules. These systems enable alarming, discreet control, metering, proportioning, scanning—with the ability to compress a wealth of control signals or data onto a standard two-wire and ground transmission line.

Available as complete systems, including control centers, or for integration into your existing set-up. Full details in new control catalog.



LUBE OIL FACILITY required remote control of 87 different pumps from 11 different mixing stations. Sparton solved problem with Bipolar DC Discreet Control System that eliminated verbal order errors, saved delays, enabled faster product switch. Operator at each supervisory point quickly selects pump or pumps assigned to his positions and controls operation with ON-OFF-EMERGENCY OFF key. Lamps indicate PUMP ON or PUMP EMERGENCY OFF for each controlled pump.



MEASURED MILE on Michigan pipe line enables more accurate product measurement, better switching control. Supervisor at station "D" controls stations "A", "B", and "C" over 20 miles of line. Line pressure and product temperature transducers transmit data to control point. Pick-ups at "A" and "B" transmit departure and arrival impulses to enable accurate measurement to transmission time of barrel.

Sparton

CONTROL SYSTEMS

SPARTON CONTROL SYSTEMS DIV.
The Sparks-Withington Company
Jackson, Michigan

☐ Please send literature. ☐ Have representative call.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

Cleats reduce slipping on football fields, but–

WALK and WORK SAFELY

on low-cost A.W. SUPER-DIAMOND

ECONOMY ROLLED STEEL FLOOR PLATE

Forty raised steel figures to the step are your assurance of foot safety. Secrets of SUPER-DIAMOND's anti-slip protection for men and rolling equipment are the diamond design and alternate spacing of figures at right angles and correct distances for maximum friction from any angle of approach. After years of usage, the diamond pattern still retains its safe, comfortable footing . . . still permits quick cleaning and draining.

Made from tough steel floor plate, SUPER-DIAMOND can be fabricated with normal shop equipment. There are no matching problems. Use it structurally, as an overlay or as a complete flooring.

No other floor plate can match A.W. SUPER-DIAMOND's *safety, durability and easy maintenance at so low a cost.*

A.W. SUPER-DIAMOND

ROLLED STEEL FLOOR PLATE

"The diamond in the rough . . . a gem of a flooring."

ALAN WOOD STEEL COMPANY

Conshohocken, Pa.

Please send A.W. SUPER-DIAMOND Booklet SD-8

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Other products: A.W. ALGRIP Abrasive Rolled Steel Floor Plate—Plates—Sheets—Strip—(Alloy and Special Grades)

For plants where oil, water and grease raise special problems of slipping accidents, we suggest a check on the special qualities of A.W. ALGRIP . . . the world's only abrasive rolled steel flooring.

How to Do It . . .

them there on three wheels, in a hurry. At the extreme right end of the upper horizontal beam there is an adjustable hand wheel which provides an easy connection of the front wheel assembly to the fire shield. The firemen can then lightly haul it away instead of laboring under a great strain.

Fire shield ready for action.

After the shield is wheeled to the fire area, the wheel assembly is easily removed and the shield placed in a vertical position ready for action.

This idea was submitted by:

Yang Tzen-yung
Maintenance Division
Kaohsiung Refinery
Chinese Petroleum Corporation
Kaohsiung, Taiwan

Erratum

Credit should have been given last month to Spence Engineering Company for furnishing PETROLEUM REFINER with the "How To Do It" item on Page 184 entitled "Use An Accessory Check List."

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

FOR CATALYTIC REFORMING

4 B&W Refractory Castables

with low iron content

B&W Kaocast

Ten years ago, B&W introduced this 3000° castable which offers a combination of high temperature use limit, as well as very low iron content. B&W Kaocast can either be gunned or cast in place.

B&W Kaocrete-LI

After two years of extensive field service, B&W adds Kaocrete-LI to low iron content castables. B&W Kaocrete-LI, which has an iron content of less than 1%, has exceptionally high strength for resistance against abrasion and erosion. It has sufficient refractoriness for use at temperatures to 2700 F. Suitable for both gunning and casting.

B&W Kaolite-LI

Another new castable with over two years of field service, B&W Kaolite-LI has high insulating properties due to its light weight (only 59 pounds per cubic foot). Its iron content is also less than 1%. It is designed to be applied with a cement gun only. Installation and maintenance time can be cut since Kaolite-LI does not require water curing and heat can be applied directly after gunning.

B&W Kaocrete-32

Developed for special high temperature service, B&W Kaocrete-32 has extremely high strength and a use limit of 3200 F. It can be poured, plastered or gunned into place.

Properties of B&W Low Iron Content Castables

		B&W Kaocast	B&W Kaocrete LI	B&W Kaolite LI	B&W Kaocrete 32
Use limit, °F		3000	2700	2300	3200
Melting point, °F		3200	3100	2700	3297
Average density lb/cu ft after firing		126	131	59	134
Average % Fe_2O_3		1.0	0.9	0.8	1.0
Cold crushing strength—psi average—after heating for 5 hrs. at:	1000 F	700	2500	350	1000
	1500 F	500	2500	350	800
	2000 F	400	1200	300	750
	2200 F	500	1300	450	1000
	2400 F	500	1600	—	2000
	2600 F	1000	6000	—	3000
	2800 F	2200	—	—	3500
	3000 F	3500	—	—	4000
	3200 F	—	—	—	5000
Permanent linear shrinkage—average % less than—after heating for 5 hrs. at:	1000 F	0.3	0.2	0.3	0.2
	1500 F	0.3	0.2	0.4	0.2
	2000 F	0.5	0.2	0.4	0.2
	2200 F	0.5	0.2	0.6	0.4
	2400 F	0.5	+0.1	—	0.5
	2600 F	0.5	—	—	0.5
	2800 F	0.5	—	—	0.5
	3000 F	0.3	—	—	0.2
	3200 F	—	—	—	0.1

Consult your B&W Representative for additional information on these and other B&W Refractories for the refining industry.

B&W REFRACTORIES PRODUCTS: B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

BABCOCK & WILCOX

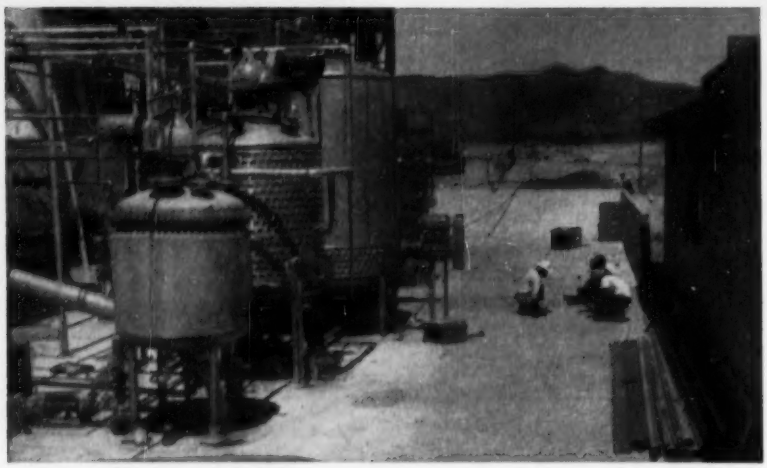
THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST. NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

EXTRA FAST DELIVERY
of *standard* Pfaudler glassed reactors now!

Pfaudler

Pfaudler Corrosioneering News Published by The Pfaudler Co., Rochester, N.Y.

Pfaudler helps Felva set up new Mexican detergent plant



THE HEART OF FELVA'S PLANT. Pfaudler equipment lined up here (left to right) consists of a 300-gallon sulfonator, 1000-gallon neutralizer, and a 3000-gallon slurry storage tank. A side-entering mixer keeps the slurry in motion. The pipe-like equipment slanting off to the left of the sulfonator is a Pfaudler heat exchanger. And on the extreme left is a partial view of the stainless cooler. Some of this equipment must withstand the highly corrosive effects of oleum. Pfaudler glassed steel and alloy equipment prove equal to the task.

Productos Quimicos Felva—synthetic detergent manufacturer of Hermosilla—began operations in June. The event culminated a two-year program of planning and building.

To our southern neighbors, the event was especially significant. Felva's plant represents only the second of its type to be owned wholly by Mexicans. To you it most likely represents the kind of contribution corrosioneering makes to the processing industries.

Here's what Pfaudler's project engineers did for Felva: They furnished complete installation instructions including site preparation, general layout, and piping drawings—together with some of the electrical drawings. They furnished specifications for the concrete and suggestions for Felva to use in negotiating plant construction contracts. They furnished on-the-spot aid during the erection and start-up stages. And one of Pfaudler's engineers even prepared design sketches of a water spray cooler, railroad tank car unloading platform, and other appurtenances to the plant—even though these were not the responsibility of *The Pfaudler Co.!*

That's the kind of engineering service you can get from Pfaudler's project engineers. Skilled in the corrosioneering of all types of processing equipment, they're well qualified to help you with *your* processing problems.

To learn more about this unique service, contact your nearest Pfaudler representative. Or mail the coupon and receive your copy of the "Buyer's Guide."

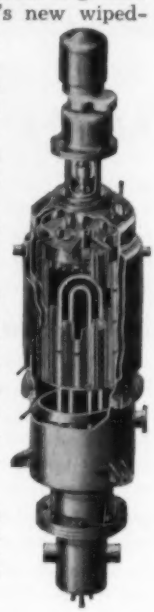
Pfaudler Annual Report available

Our fiscal year—a highly successful one—ended May 31. A report of Pfaudler's activities during that year is now available to those of you who share our interest in Pfaudler's progress.

Mail the coupon today for your free copy of the 1956 Pfaudler Annual Report.

Unique new vacuum still helps probe new profit areas

You can test your own product—and in that way uncover areas of greater profit—with Pfaudler's new wiped-film evaporator for vacuum distillation.



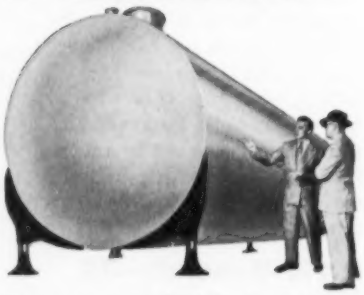
A floating carbon blade cleanly wipes the peripheral evaporating surface to promote a very thin film and turbulence—creating higher heat transfer rates and faster evaporation.

Two models are available now: a two-inch laboratory evaporator and a 12-inch pilot plant unit. For more information, contact your Pfaudler representative.

Right — Twelve inch pilot plant evaporator. Vacuums to 0.1 mm or lower; temperatures up to 700° F.; very high capacities.

CHEMSTOR spells low-cost storage

New vertical design added to line



Store your product in inexpensive Chemstor tanks—the glassed steel tanks that cost only 25 cents per gallon of capacity in the larger sizes. Size range is 750 to 35,000 gallons. You get the corrosion resistance of glass *plus* the working strength of steel. Nothing beats glassed steel for keeping your product free from contamination. Chemstor tanks are easy to clean—almost nothing sticks to glass!

For further information, check Bulletin 918 on the coupon and mail it in today.

For more data on advertised products, use Readers' Service Cards, last page.

Corrosioneering News

Quick facts about services and equipment available to help you reduce corrosion and processing costs.

How to cut time *and* cost of your centrifuging

It's no longer necessary for your centrifuging to be an expensive and time-consuming "batch" type operation.

With a Titan Superjector Centrifuge, you get:

- *continuous* removal of solids from one or two liquids
- *continuous* concentration of solids by removal of liquid from slurries—and discharge of solids in a pre-determined dry state.

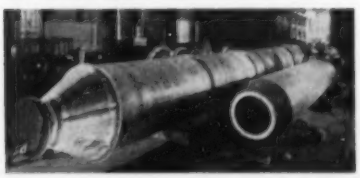
While rotating at full speed, the Superjector discharges solids deposited within the centrifugal bowl and *thus cleans itself*. You benefit from reduced labor costs, increased production, and improved product!

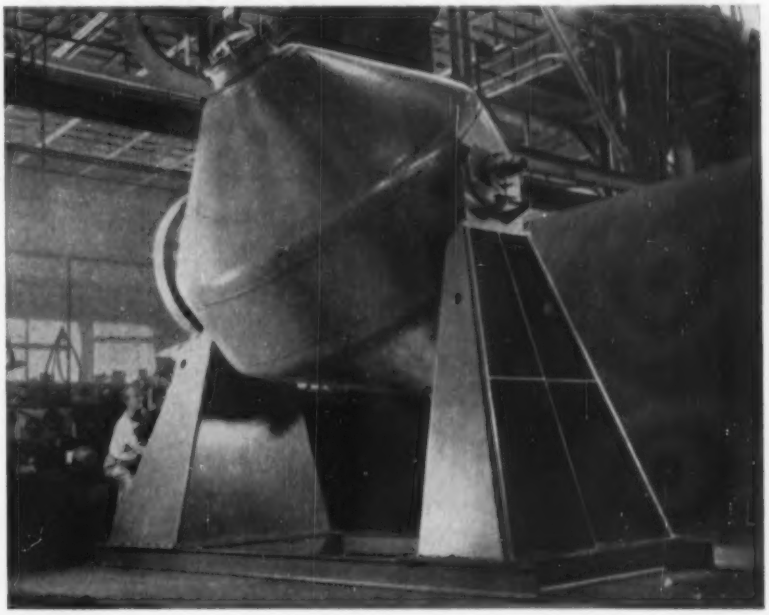
Once you see the uniqueness of its design, you'll understand just how economical and time-saving the Titan Superjector can be. Bulletin 930 gives you full details.

Nickel-clad columns

Here are two nickel-clad columns designed for petrochemical service. The unit on the left is 46 feet long, the other 56 feet. Pfaudler's experience with both glassed steel *and* alloy columns qualify our engineers as impartial assistants to you in *your* column selection problems. Make doubly sure you order the *right* column by checking with us before you buy.

Send for Bulletin 940 and Data Sheet No. 25.





Big new conical dryer-blender speed-dries 165-cubic-foot batch!

Now you can speed-dry larger batches of highly corrosive products than ever before. The enormous working capacity of this giant dryer-blender permits fast drying of up to 165 cubic feet of material.

You get more than just a *dryer* with the Pfaudler unit—you get a dryer-*blender* that offers these important benefits:

- **Higher Heat Transfer** through uniformly narrow jacket space.
- **Lower Power Requirements** because units of this design are unencumbered by "extra" water in the jacket.
- **Improved Heat Transfer** due to the much greater *jacket surface area* than you'll find in other units.
- **Corrosion Resistance** of acid-alkali-resistant glassed steel.
- **Even Drying *and* Blending** produced by established method of *proper* tumbling.

You'll enjoy all these benefits with any Pfaudler conical dryer-blender. Exclusive features of the big new *eight-foot* dryer-blender include 1) lubricated stuffing box, 2) gear-driven unit, 3) 15-hp. explosion-proof motor *with magnetic brake*, and 4) *pre-formed* stand.

On the right is a close-up view of the new drive unit. There's no possibility of "bucket rolling" with this unit because of the new magnetic brake. Normally turning at eight rpm, the bucket alone—fully charged—weighs ten tons!

Learn more about this unique dryer-blender. Mail the coupon and receive without obligation your copy of Data Sheet 26.

THE PFAUDLER CO., Dept. PR-11 , Rochester 3, N. Y.

Please send me: ☐ Buyer's Guide. ☐ Pfaudler 1956 Annual Report. ☐ Bulletin 918—Pfaudler Chemstor Tanks. ☐ Bulletin 930—The Titan Superjector. ☐ Bulletin 940—Columns *Glassed Steel & Alloy*. ☐ Pfaudler Data Sheet 25—Columns. ☐ Pfaudler Data Sheet 26—Dryer-blenders.

Name.....

Title.....

Company.....

Address.....

City.....Zone.....State.....

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Europe Gets U.S. Engineering Know-How

West German Plant To Use Direct-Air Oxidation Method

ETHYLENE OXIDE BY THE DIRECT air oxidation of ethylene will be produced at the rate of 26,000,000 pounds per year in a new plant to be erected by Farbenfabriken Bayer, Aktiengesellschaft at Leverkusen, Germany, according to a contract signed recently with Scientific Design Company, Inc., New York, N. Y. The new plant, will operate under license on SD's direct air-oxidation process, adapted to the local feeds and conditions of Bayer by SD. Under the contract, SD will perform all engineering in the U. S. according to German specifications and standards.

The ethylene oxide plant will be part of a large new integrated petrochemical unit. The ethylene feed for the oxide plant will come from a crude-oil cracking plant to be erected and operated as part of Bayer's petrochemical development.

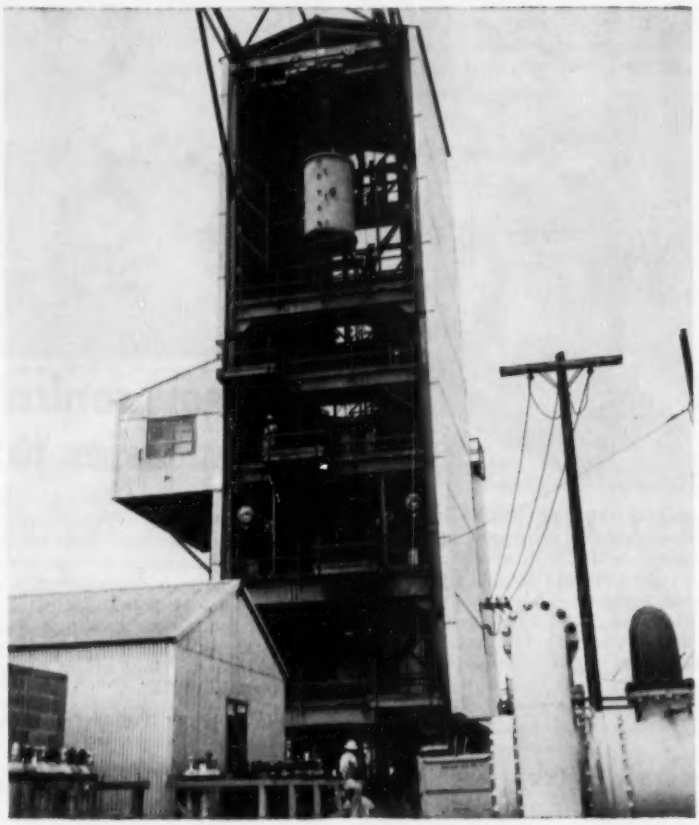
The process has been under development for seven years at SD's laboratory and pilot plant at Port Washington, N. Y. Early large-scale pilot plant work was conducted in 1948 in England jointly with Petrocarbon, Ltd. The first commercial plant was built for Naphtachimie in France in 1953, and the second by Allied Chemical at Orange, Texas, in 1954. Another plant was designed for Société Chimique des Dérivés du Pétrole in Belgium, and General Aniline is building a plant at Linden, N. J. to go on stream next year. In Japan, Mitsui is building an SD oxide plant as part of a large new petrochemical development while Naphtachimie is expanding its original plant to nearly double the original capacity. SD will also design and engineer another oxide plant for a European firm, not yet publicly announced.

Ethylene oxide finds its largest market in the manufacture of ethylene glycol anti-freeze. It is also used in the formulation of detergents, resins for paint, synthetic fibers and many other chemical products.

For a complete description of Scientific Designs' ethylene oxide process please refer to the PETROLEUM REFINER Petrochemical Handbook, December 1955, pg. 153.

Production of ethylene oxide has

For Fluidizing Solids



Two-ton section of reactor in Esso Research and Engineering Company's new fluidized-solids pilot plant is hoisted into position at site in Linden, N. J.

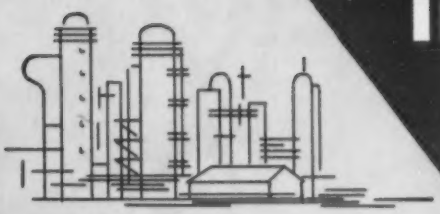
The reactor is built in six two-ton sections, any number of which can be removed to allow engineers to make experimental changes inside the vessel. The five-ton crane on top of the unit is used to lift sections in and out of position.

More than 200 stoppered "portholes" stud the huge reactor. Through them, samples of air can be removed for analysis while the plant is on stream.

Other features of the pilot plant include a made-to-order, air-operated diaphragm valve; a control house located at the third level, rather than on the ground, to place its battery of analytical equipment equidistant from the top and bottom heads of the reactor; a public address system with loud-speakers on all floors of the unit; and electronic instruments instead of the pneumatic ones generally used.

Finest

IN THE FIELD



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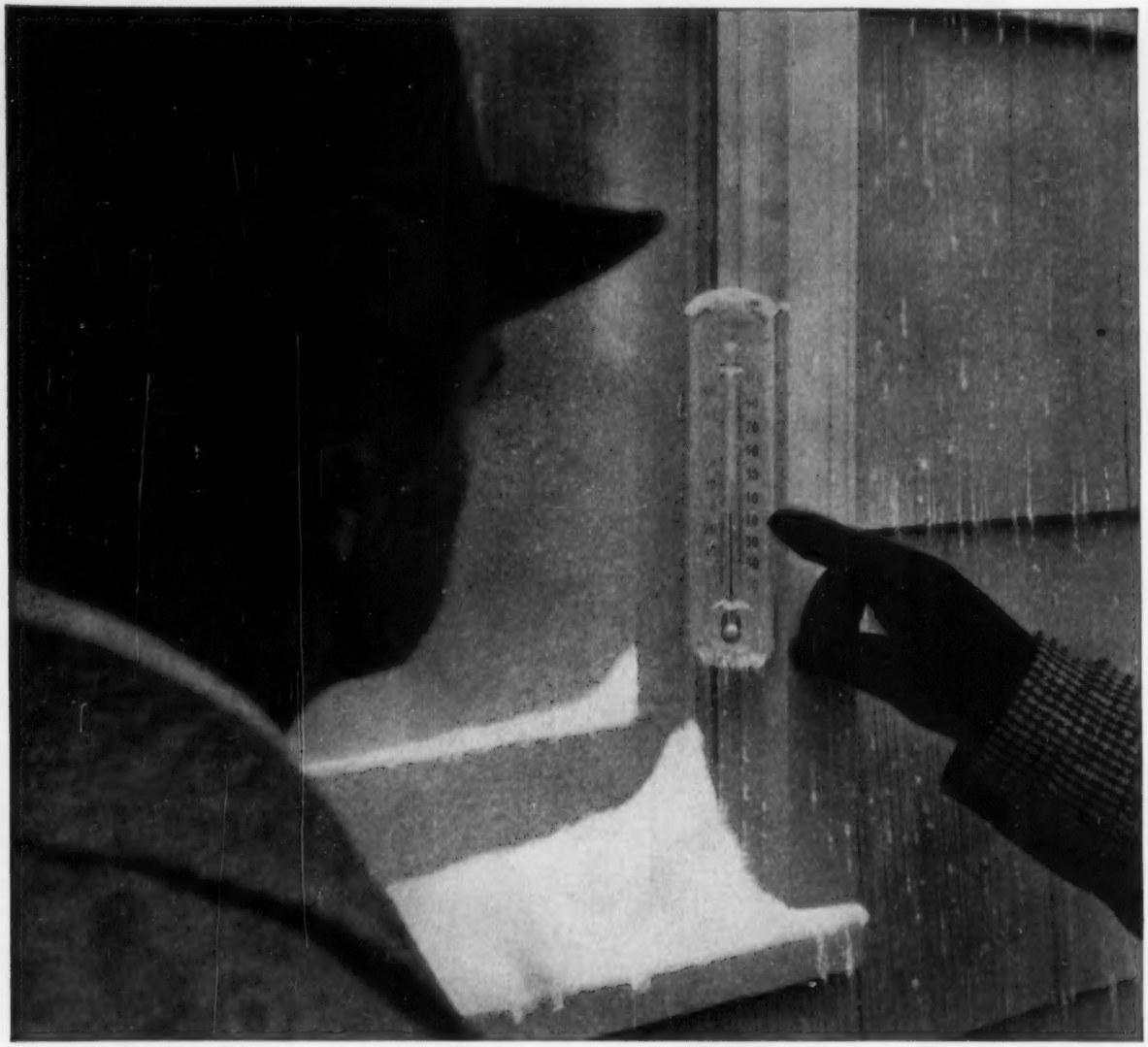


"Cold weather reminds me of what Pritchard did at Tioga!"

"What has Pritchard got to do with the weather? And where or what is Tioga?"

"Pritchard had plenty to do with the weather! You mean I've never told you about Tioga?"

"No, you haven't. What is it?"

"Tioga is a place in North Dakota where Signal Oil and Gas Company has its new natural gasoline plant. Now, that's where Pritchard really went to work! They designed and engineered the whole plant. They sure had a tough weather problem to whip!"

"Was it bad?"

"Bad? I'll say so! Down to minus 40 degrees or less in the winter and then up to 110 in the summer. You know how they solved it?"

"How?"

"Dry distillation! They didn't use a bit of steam in the gasoline recovery process. Imagine, gasoline recovery without using any steam. You know, I'm not too surprised."

"What makes you say that?"

"I know Pritchard. They cut their eye teeth on problems like Tioga."

J. F. PRITCHARD & CO.
4625 Roanoke Parkway, Kansas City 12, Mo.

"Cold weather reminds me of what Pritchard did at Tioga!"

Dry Distillation Features Signal's Tioga Plant— Designed and Engineered by Pritchard

Signal Oil and Gas Company's new Tioga, North Dakota natural gasoline plant features dry distillation, with no steam used in the gasoline recovery process.

The entire plant was designed and engineered by Pritchard.

This plant was designed for extremely cold weather operations, with temperatures —40° F. or below in the winter; up to 110° F. in the summer.

Just another in the long parade of successful installations, the Signal plant is further proof that Pritchard designers and engineers have the skill to design facilities for you.

Contact Pritchard immediately for full details!

FREE TIOGA BROCHURE!

TIOGA

Write today for free Tioga Brochure. This beautiful brochure tells a fascinating picture story of the entire Tioga installation. Here's a book you'll want to keep. Get it by jotting a note on your company letterhead. No obligation whatever.

INDUSTRY'S PARTNER FOR PROGRESS

J.F. Pritchard & Co.
ENGINEERS • CONSTRUCTORS
Dept. 496 , 4625 Roanoke Parkway
Kansas City 12, Mo.

SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES
BOSTON, CHICAGO, BUFFALO, HOUSTON, NEW YORK, PITTSBURGH

Who's Building...

increased for the chemical industry. In 1953 production was about 745 million pounds per year, but when all plants now under construction are operating in 1957, production will exceed 1 billion pounds per year.

Fluor Maintenance, Inc. of Martinez, Calif., a subsidiary of The Fluor Corporation, Ltd., Los Angeles, has been awarded a contract by Atomics International, a division of North American Aviation, Inc., to install the reactor portion and related systems and conduct construction work in connection with the Organic Moderated Reactor Experiment (OMRE) Atomics International is building and will install for the Atomic Energy Commission.

Borden Company will build a chemical plant in Dominguez, Calif. for the production of pentaerythritol and formaldehyde. The plant will have a 10-million pound annual production capacity for pentaerythritol, and a 40-million pound production capacity for formaldehyde.

Added to its five other formaldehyde units, the new unit will increase the company's capacity by 20 percent. Borden does not presently produce pentaerythritol.

The Texas Company will build one of the world's largest fluid catalytic cracking units at its refinery at Port Arthur, Texas. The new unit will have a rated thruput capacity of 90,000 barrels per day, including 30,000 barrels of recycle stock.

A site also is being prepared for an 80,000 barrel per day capacity vacuum pipe still at the Port Arthur works. Construction on this unit is scheduled to begin early next year, and it is expected to be completed in the latter part of 1957.

The new vacuum pipe still will replace existing units having a daily charge capacity of 60,000 barrels, resulting in a net increase of 20,000 barrels per day in the crude capacity of Texaco's Port Arthur refinery.

E. I. du Pont de Nemours & Company will build a new plant to produce 40 million pounds of "Orlon" staple and tow annually. The plant will be built at the company's large acetate yarn manufacturing unit in Waynesboro, Va. At the present time, Du Pont has an annual capacity of over 60 million pounds of "Orlon" staple and tow at its Camden, S. C. plant.

Dow Chemical Company will construct a new petrochemical plant in Bay City, Mich. The plant will draw petroleum products from its newly acquired Bay Refinery for use in making ethylene. This ethylene will then be shipped to the company's Midland plant to be used in making plastics.

Cost of the new plant was not disclosed, but completion is expected by January 1958.

The Pure Oil Company placed its new ultraformer on stream at Smith Bluff, Nederland, November 1.

Ethyl Corporation announces plans for an antiknock compound manufacturing plant in California. The new plant will be located in the San Francisco Bay area, and will be large enough to serve the needs of the West Coast oil industry for "Ethyl"

FILTER CLOTHS

Die-Cut to Your Press Plate Dimensions

DEVELOPED ESPECIALLY FOR THE REFINING INDUSTRY is our new filter fabric No. 621, shown here. It's glass-like surface releases the cake quickly and easily. Foots can't penetrate the thread fibers.

EASILY CLEANED WITHOUT SCRAPING. Just whip the cloth to release the cake. To wash, you rihse the cloth by hand in warm water.

ELIMINATE EXPENSIVE ROLL GOODS INVENTORIES. No shrinkage to worry about. We supply you filter cloths, precision die-cut to your pattern and specifications, neatly packaged and ready to use. Cloths are supplied in all types of cotton and synthetic fabrics.

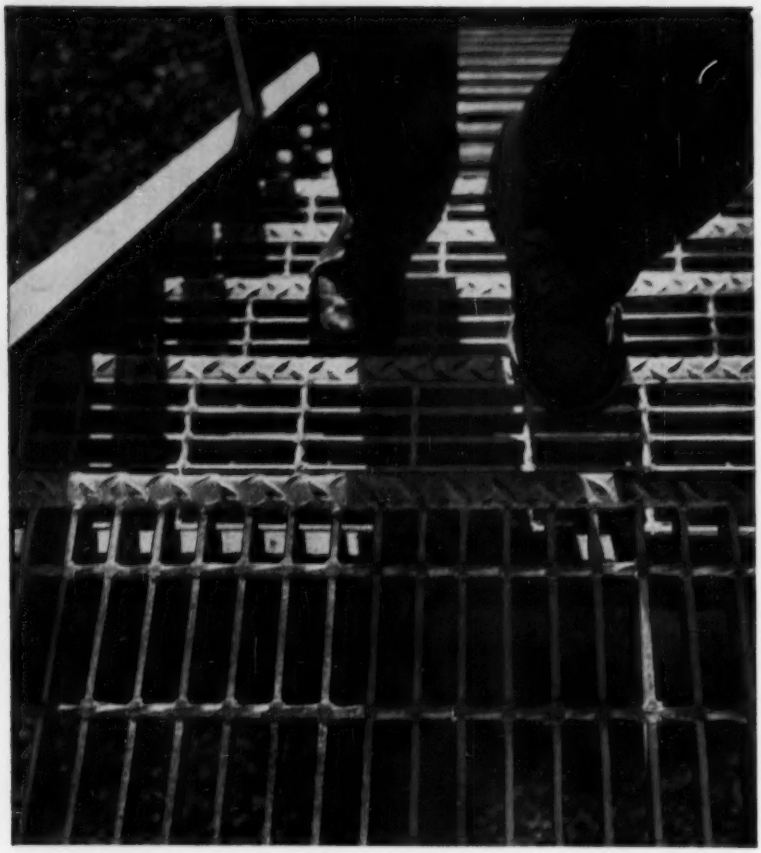
SAVE ON DOWN TIME. Always have the right filter cloth in stock.

FOR QUOTES AND SAMPLES send press plate dimensions and details on your filtering operations.

Specialists For Over 25 Years In The Design and Manufacture of Filter Blankets and All Types of Wet and Dry Filter Media. Suppliers of Filter Discs in All Types of Material.

FILTER FABRICS
INCORPORATED
1550 EAST 17TH ST. CLEVELAND 14, OHIO
CHERRY 1-0456
PLANTS: CLEVELAND, OHIO • GOSHEN, INDIANA

For more data on advertised products, use Readers' Service Cards, last page.



... make every step a safe step

BLAW-KNOX ELECTROFORGED® STEEL GRATING and STAIR TREADS

On stair treads, walkways, catwalks, platforms and floors—both indoors and outdoors—you can provide safe walking conditions. For Blaw-Knox Electroforged Steel Grating brings you these exclusive features:

1. rigid one-piece construction—easy to install
2. non-slip twisted crossbar—for safe footing
3. three types of bearing bars
   - square bars—for smoothest walking surface
   - knurled bars (Furro-Grip)—for extra safety plus relatively smooth walking surface
   - serrated bars—for maximum safety under extremely hazardous skid conditions
4. no sharp corners to clog—self-cleaning
5. all surfaces accessible—easy to paint
6. maximum open area—for light and ventilation

Write for your copy of new Bulletin No. 2486 —or send dimensional sketch for quotation.

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY
Equipment Division
1104 Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania

GRATING APPLICATIONS: floors • platforms • walkways • catwalks • stair treads • fan guards • shelving • and many other uses, both outdoors and indoors, for versatile steel grating

Who's Building...

antiknock compounds.

Esso Petroleum Company, Ltd., has announced that it is considering construction of a $56-million oil refinery in the Milford Haven dock area of West Wales. Present plans call for a plant capable of refining five million tons of crude petroleum a year.

Firestone Tire and Rubber Company has abandoned plans for a styrene plant at Orange, Texas, but the firm is going to go ahead with a butadiene plant there. A reduction of 4 cents a pound in the price of styrene brought about the change in plans. The butadiene plant will have a capacity of 40,000 tons a year, and is scheduled for completion early next year.

Shell Haven in the Thames estuary is planning a new crude distillation unit, which will almost double the capacity of the refinery. The new distiller is designed for 11,000 tons a day (80,000 barrels a day) of crude and will raise the refinery capacity to 7¾ million tons per year. Total cost of the new unit, with ancillary equipment, is estimated at $18 million, and on stream date is expected by the end of 1958.

The new plant incorporates several novel features, one of which is the furnace which will be one of the largest in use in the oil industry, having a heat absorption of over 200 million BTU per hour.

The distillation unit will be erected by E. B. Badger and Sons, Ltd.

British Petroleum, Caltex, Shell, and Socony, the four major distributors of oil products in Turkey, are contemplating building a jointly-owned 20,000-barrel-a-day refinery near Istanbul.

Standard-Vacuum has made plans to build a refinery in the Philippines. It will cost approximately $35 million and have a crude oil charging capacity of 21,000 barrels a day.

Tidewater Oil Company has completed and placed in operation a new gas processing plant, the second of three major units being built in the company's current western expansion program. A month ago the company disclosed that a 24,000-barrel-a-day hydrodesulfurizer had been completed and turned over to it for operation.

The gas processing plant, the fifth at the Avon Flying A Refinery four miles east of Martinez, California, has a capacity of 88,000,000 cubic feet a day. It will extract propane, butane, and gasoline from gas piped from the yet-to-be-completed fluid coking unit and the presently existing thermal cracking units.

Air Products, Inc., Allentown, Pa., will build an air separation plant to recover nitrogen and oxygen, and a hydrogen purification plant for synthesis of ammonia in Venezuela. The two plants will be the first such plants in South America, and the ammonia, 120 tons per day, will be employed to make explosives, fertilizers and chemicals for domestic consumption.

The American Oil Company has requested bids for the construction of a second Ultraformer at its Texas City refinery. The unit will have a capacity of 21,-

For more data on advertised products, use Readers' Service Cards, last page.

THESE MIDWEST "LONG TANGENT" ELBOWS SAVED $4121 IN PIPE

MIDWEST "LONG TANGENT" ELBOWS COST NO MORE THAN OTHER ELBOWS

Here are 1227 Midwest "Long Tangent" Elbows (12", 14" and 16" standard weight) ready for shipment to a chemical plant. Each Midwest "Long Tangent" Elbow has a straight section on each end equal in length to ¼ the nominal pipe size. Thus a 12" elbow saves 6" of 12" pipe while a 16" elbow saves 8" of 16" pipe. It doesn't take long to save a lot of pipe and a lot of money . . . in this instance $4121.

But saving pipe is not the only advantage of Midwest "Long Tangent" Elbows. They often eliminate short nipples and their extra welds . . . save time and money in lining up and clamping pipe and fittings . . . slip-on flanges are more easily applied. For all the facts, write for Catalog 54.

MIDWEST PIPING COMPANY, INC.
Main Office: 1450 South Second Street, St. Louis 4, Mo.
Plants: St. Louis, Clifton, N. J., Los Angeles and Boston

Sales Offices
New York 7—50 Church St. • Chicago 3—79 West Monroe St.
Boston 27—426 First St. • Los Angeles 33—520 Anderson St.
Houston 2—1213 Capitol Ave. • Tulsa 3—224 Wright Bldg.
Cleveland 14—616 St. Clair Ave. • San Francisco 11—420 Market St. • Oneida, N. Y.
STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

MIDWEST WELDING FITTINGS

MIDWEST WELDING FITTINGS Improve Piping Design and Reduce Costs

7055

Who's Building . . .

000 barrels per day, and will be equipped with facilities for naphtha desulphurization. Completion is expected before the end of 1957.

The Fluor Corporation, Ltd., of Los Angeles has been awarded a contract to engineer and construct a catalytic desulfurization unit for Great Northern Oil Company at its Pine Bend, Minnesota refinery.

Field construction has begun, and completion is scheduled for early December, 1956. Total cost of the project is approximately $1,000,000.

General Petroleum Corporation has unveiled plans for an $8 million expansion program at its Torrance, California refinery. The project includes a 12,000 barrel per day catalytic Sovaformer for producing high octane gasoline components and additional gasoline fractionating and offsite facilities.

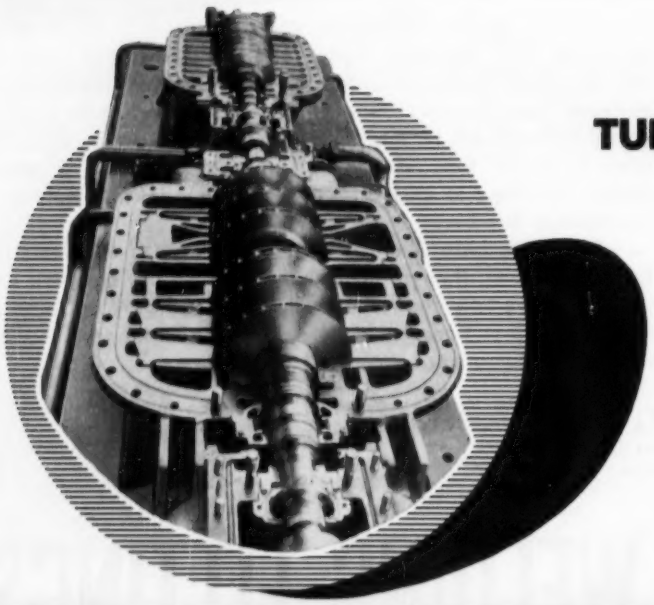
The major portion of the new facilities will be constructed by the Ralph M. Parsons Company. Estimated completion date is October, 1957.

B. F. Goodrich Chemical Company will build a $2,500,000 plant to manufacture specialty acrylic polymers at Calvert City, Ky. Construction will start immediately and will consist of three units, the process building, shop, and warehouse. Work on the shop and warehouse building has already been started. Wigton-Abbott Corporation of Plainfield, New Jersey has been named as general contractor. Expected completion date is October, 1957.

Plant Nears Completion—
Work progresses on schedule as the first of two 87-ton reactors is lifted into position at Firestone Tire & Rubber Company's butadiene plant at Orange, Texas. Scheduled for completion in early 1957, the plant will utilize materials from Texas oil fields to produce butadiene.

Houilleres du Bassin de Lorraine have placed with the Engineering Division of Societe Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.), Liege (Belgium) a contract for the planning and construction of a styrene monomer plant based on the plans, process information and know-how supplied by Koppers Com-

Next Construction Boxscore will appear in the January issue.



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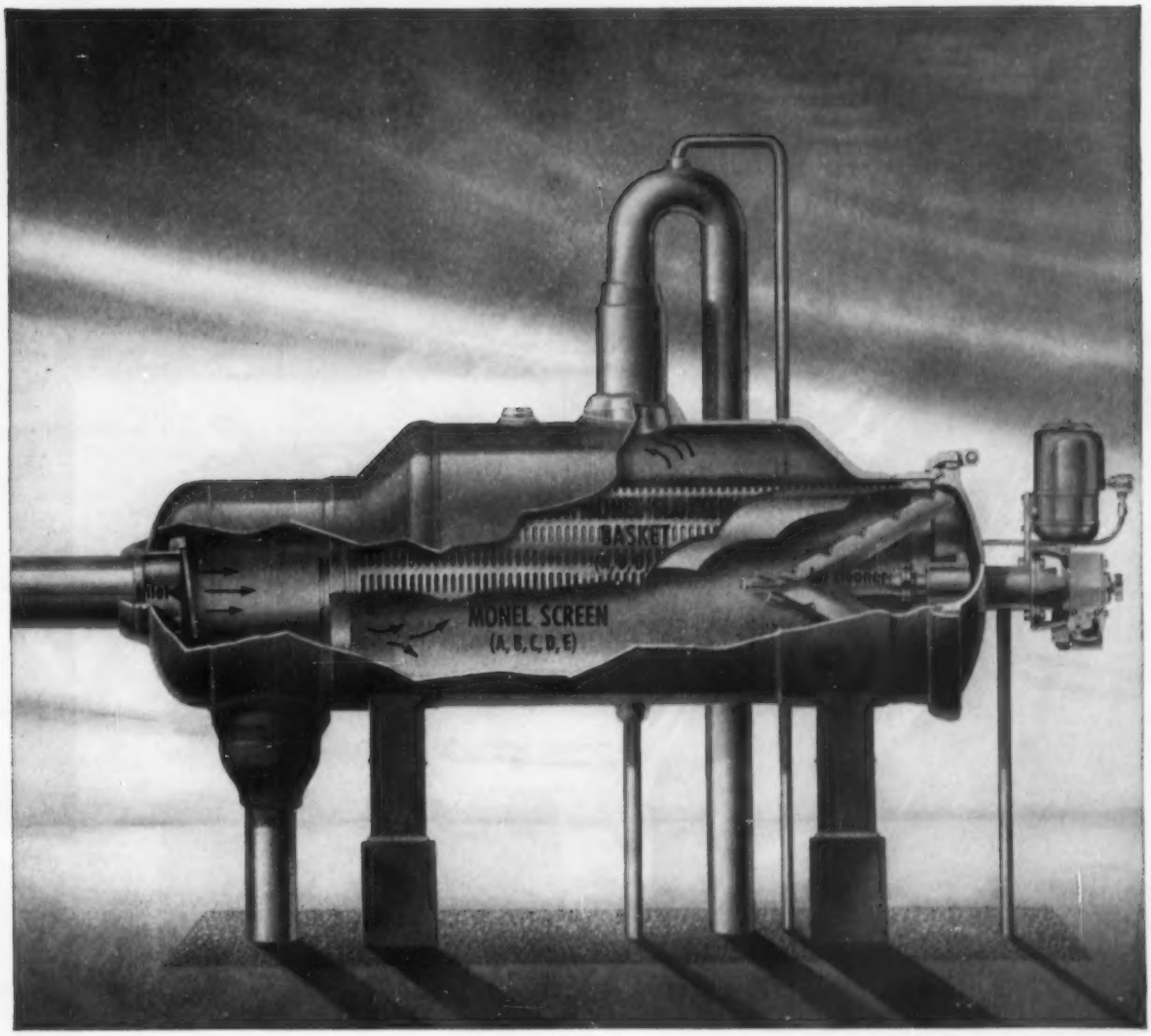

How Monel improves the Thornhill-Craver strainer

A. Resists corrosives in refined products lines **B.** Retains shape under high pressures **C.** Withstands erosive attack by fast-moving gas-bubbles or moisture particles **D.** Resists wear by entrained solids **E.** Aids slough-off of gummy filtrate

Unique Thornhill-Craver horizontal strainer filters streams pressured to 400 psi. Jet cleaned without dismantling, manually (5 minutes, one man) or automatically. Details from Thornhill-Craver Company, Inc., P.O. Box 1184, Houston 1, Texas.

With Monel* nickel-copper alloy, the Thornhill-Craver strainer is better able to withstand the corrosives found in today's refinery products and intermediates.

Recent inspections revealed no deterioration of Monel parts after 4½ years.

Monel and other Inco Nickel alloys are used in thousands of locations and many different types of drilling, production and refining equipment. *They have proven uniquely resistant to corrosion, and well able to meet a wide range of severe physical requirements.* For assistance in their application, contact Inco's Development and Research Division.

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67 Wall Street New York 5, N. Y.

INCO TRADE MARK **NICKEL ALLOYS**

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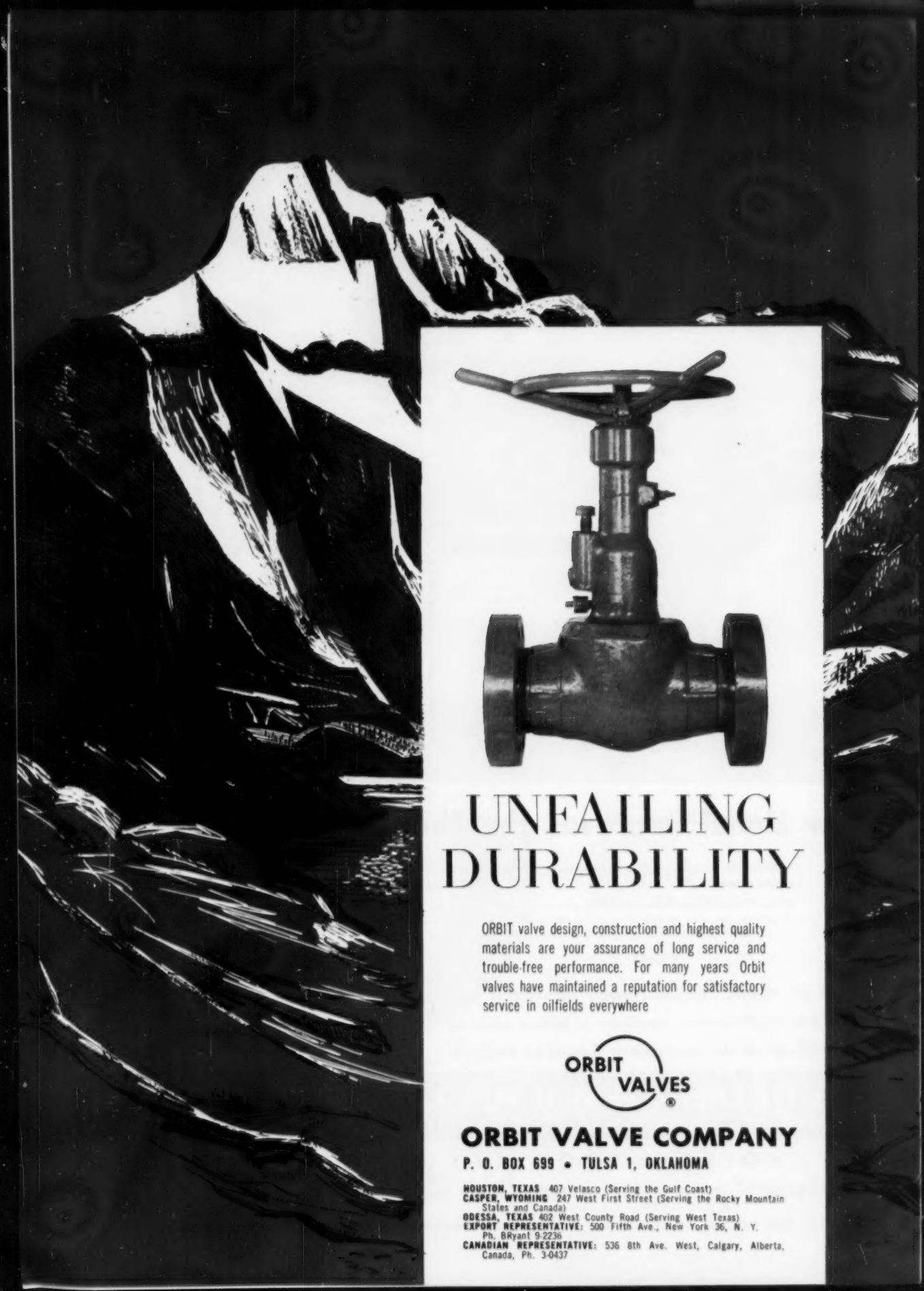
For more data on advertised products, use Readers' Service Cards, last page.



UNFAILING DURABILITY

ORBIT valve design, construction and highest quality materials are your assurance of long service and trouble-free performance. For many years Orbit valves have maintained a reputation for satisfactory service in oilfields everywhere

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ORBIT VALVE COMPANY

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ODESSA, TEXAS 402 West County Road (Serving West Texas)
EXPORT REPRESENTATIVE: 500 Fifth Ave., New York 36, N. Y. Ph. BRyant 9-2236
CANADIAN REPRESENTATIVE: 536 8th Ave. West, Calgary, Alberta, Canada, Ph. 3-0437

Who's Building...

pany, Inc. This plant will be installed in Carling (Moselle).

This is the second styrene monomer plant that S.B.A. has constructed in France according to the process information supplied by Koppers Company, Inc. The first installation of this type has been erected in Mazingarbe for ethyl-synthese and is already in operation.

Petroleo Brasileiro S. A. (Petrobras) plans to start construction on a new 90,000 barrel-a-day refinery in Rio de Janeiro. In addition, it will continue work on expanding the Mataripe refinery near the Bahia fields from 7,000 to 37,000 barrels a day.

Sinclair Oil & Gas Company and Skelly Oil Company have placed in operation their new gas products plant in the Hulldale field, 12 miles northeast of Eldorado in Schleicher County, Texas. Sinclair is the operator and the plant will be known as the Sinclair gas products plant No. 23.

The plant has capacity for compressing 15,000,000 cubic feet of oil-well gas a day, and the other processing facilities have a capacity for handling 20,000,000 cubic feet. The plant will initially handle approximately 140,000,000 cubic feet of gas a month from which approximately 1,600,000 gallons of natural gasoline, butane and propane will be recovered.

The American Oil Company plans to build a crude and vacuum distillation unit for processing 25,000 barrels of oil a day for the production of asphalt at its Yorktown, Va., refinery now nearing completion. Engineering and design work for the construction of this new asphalt processing unit has already started. Recently the company announced that the first gasoline ever produced in Virginia would be manufactured in early November at the originally announced 35,000 barrel-a-day refinery at Yorktown. Full operation of the gasoline refinery is scheduled for early 1957.

The decision to add the 25,000 barrel-a-day asphalt capacity at Yorktown is part of the company's long range program to expand facilities to meet the needs for road building materials created by the 13-year Federal highway building program.

Izmit, Turkey, a port located 70 miles south of Istanbul, is said to be the site of a $15-million refinery. William Blair, a Chicago financier with U. S. banking connections is reportedly putting up $10 million with the remainder of the capital coming from Turkish origin.

Imperial Oil Company has awarded a contract to The Fluor Corporation of Canada, Ltd., for construction of a new detergent alkylate plant. Work will start on the site adjacent to the company's Sarnia refinery this fall and the plant is expected to be completed by the middle of next year.

The plant which was announced last January will have a yearly capacity of 30 million pounds of detergent alkylate (dodecyl benzene). It will use gases produced in the refinery operations to also make smaller quantities of other alkyl aromatic compounds as well as tripropylene and tetraproylene. These are chemical raw materials used in making synthetic deter-

toughest tube maintenance jobs are made easy with AIRETOOL equipment

See for yourself why so many refinery engineers specify AIRETOOL for their tube maintenance programs. AIRETOOL Equipment handles easy . . . is rugged, packs plenty of power and speed, won't bog down or break down during use. AIRETOOL does the *best* job, quickly, economically.

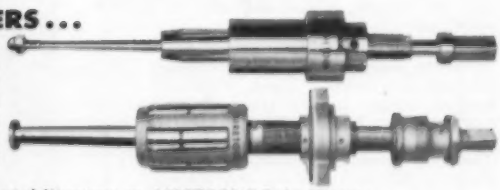
POWERFUL...FAST CUTTING TUBE CLEANERS quickly and thoroughly remove even hardest scale and deposits. Air driven motors in various sizes and speeds. P-Type cleaner head shown, is just one of many types available.

LIGHT...HANDY INTERNAL TUBE CUTTER

New . . . removes leaky or damaged tubes in *minutes!* Cuts steel or non-ferrous tubes through tube sheets 1" to 4" thick. Air or electric driven motor.

TUBE EXPANDERS...

Parallel rolling . . . self-feeding...AIRETOOL Tube Expanders roll tight, accurate tube joints with maximum bond, uniform expansion and tightness throughout full thickness of tube sheet.



Write for illustrated literature on AIRETOOL'S Tube Maintenance Equipment, or see your nearest Airetool Representative.

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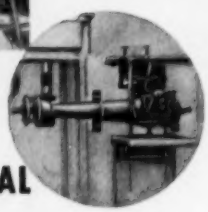
VERTICAL



OR

HORIZONTAL

many more hours on stream without forced shutdown with NATIONAL AIROIL

OIL-GAS TANDEM COMBUSTION UNITS

Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . **plus:** special, precast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner changeover.

VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

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INDUSTRIAL OIL BURNERS, GAS BURNERS, AND FURNACE EQUIPMENT

Who's Building . . .

gents, lubricating oil additives, and other industrial chemicals.

Natural Gas Product Company's new $850,000 skid-mounted refrigeration-type propane and butane plant at Roggen, Colo., is about 50 percent complete. The facility, which will be operated by New Drilling Company, will process 6,000,000 cubic feet of gas daily from the Roggen, Kiowa Creek, Orchard, Riverside, and surrounding fields. Colorado Interstate Gas Company will take dry gas from the plant.

Oil Shale Corporation will construct its main pilot plant in Denver. The plant will be based on the Swedish Aspeco process for extracting oil from shale.

Stearns-Roger Manufacturing Company has the contract to build the $100,000 plant which will have a capacity of 24 tons a day. The Denver Research Institute has completed a prepilot plant which can process 300 pounds of shale an hour.

Now that the Institute has finished the heat-treatment phase of its research, Stearns-Roger can proceed with the raw shale heating equipment at the main pilot plant. This phase is scheduled to be in operation by mid-November.

Southland Company will undertake a program of expansion and modernization which will eventually triple the size of its recently purchased 6,000-barrel-a-day refinery in Memphis. Actually the expansion will be in two stages reaching 12,000 barrels a day by February, 1957, and about 22,000 barrels a day by October, 1957.

The construction calls for increasing capacity of the crude unit through modification, installation of a larger kiln for the cracker, and the building of a new alkylation unit.

At the same time, an affiliated company, Southland Oil Company is completing plans for an all new 15,000-barrel-a-day refinery near Black Point, just southeast of Tampa, Fla.

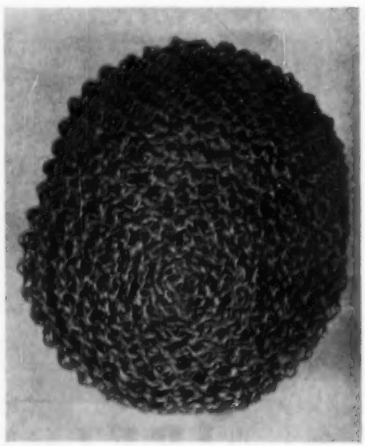
Standard Oil Company (Ohio) is deviating from the usual in several ways in designing its new 60,000-barrel-a-day refinery at Toledo, Ohio. The integrated plant, a one package deal, will replace all existing facilities except two alkylation units and a rerun unit. The rest of the present plant will be put in "moth balls" for stand-by capacity.

Measurement and control of particular operations of the new refinery will be available to each individual in charge of the various processing sections. Those controls that are best decentralized will be located at a common control point while other controls will be placed at the most suitable locations. Also, control work of a basically similar type will be assigned horizontally.

Critical portions of the operation requiring prompt correction will be controlled from a communications center. It will be possible to determine the exact status of any unit of the refinery from this center.

Tidewater Oil Company has begun operations at its large crude oil distillation unit, the first refining unit to be completed at the company's new Delaware Flying A

GOODLOE TOWER PACKING



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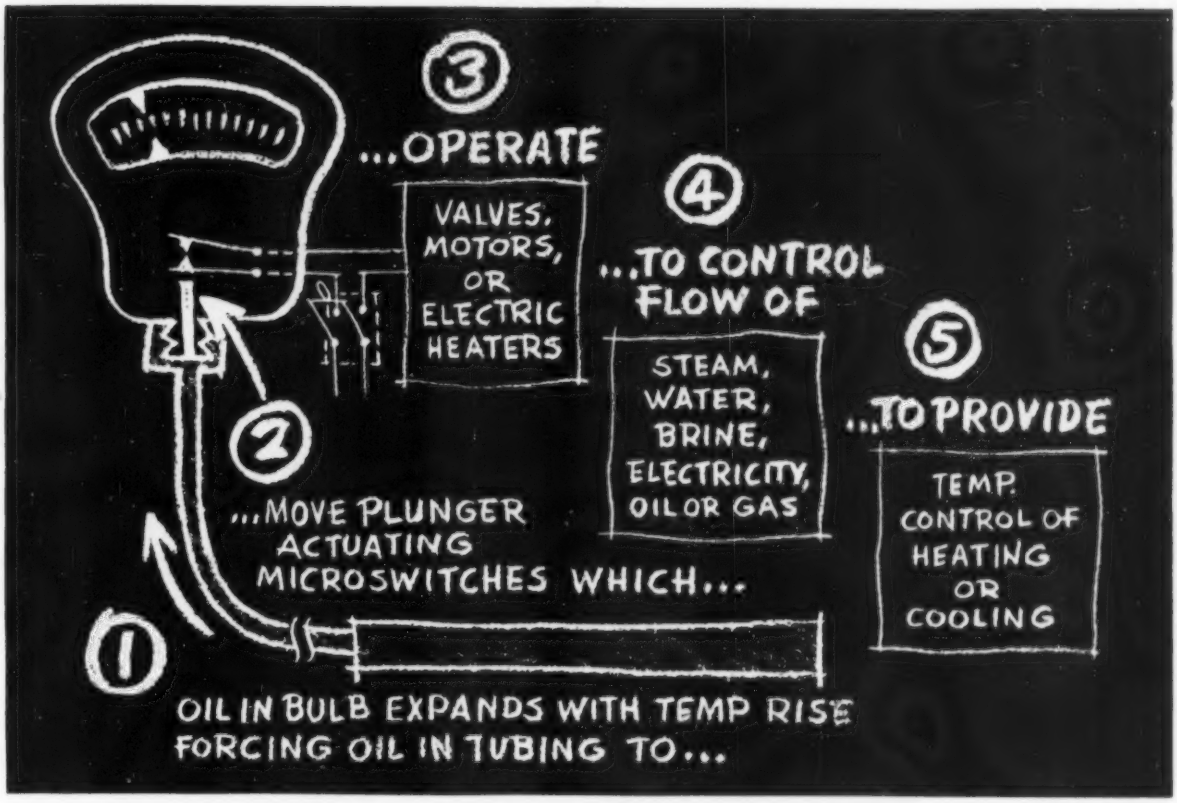

INDICATING

Automatic Temperature Control

It's simple...dependable!

That rough sketch above tells the story. It shows Sarco's simple electric indicating temperature control . . . and what it can do for you.

Really mighty simple, isn't it? Yet, it's adjustable, indicating and provides dependable accuracy to ± ½°F. No gadgets that call for a technician to read and repair! So simple, so trouble-free . . . maintenance is seldom, if ever, needed.

Turn one knob to change the temperature control setting. Large, easy-to-read scale shows you both the actual and the set temperature.

SEQUENCE CONTROL

And this Sarco electric temperature control is versatile . . . it offers you many sequence combinations such as:

- **Step-heating**
- **Heating and cooling**
- **Wide limit control**
- **Temperature control plus operation of signal devices**

Cost . . . only about $100! It's good economy to specify AUTOMATIC temperature control for ALL control jobs, not just the big ones. So mail the coupon now for complete information.

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Please send information on your simple, inexpensive temperature controllers:

☐ Self-powered type for use on_____

☐ Electric indicating type for use on_____

Name_____

Firm_____

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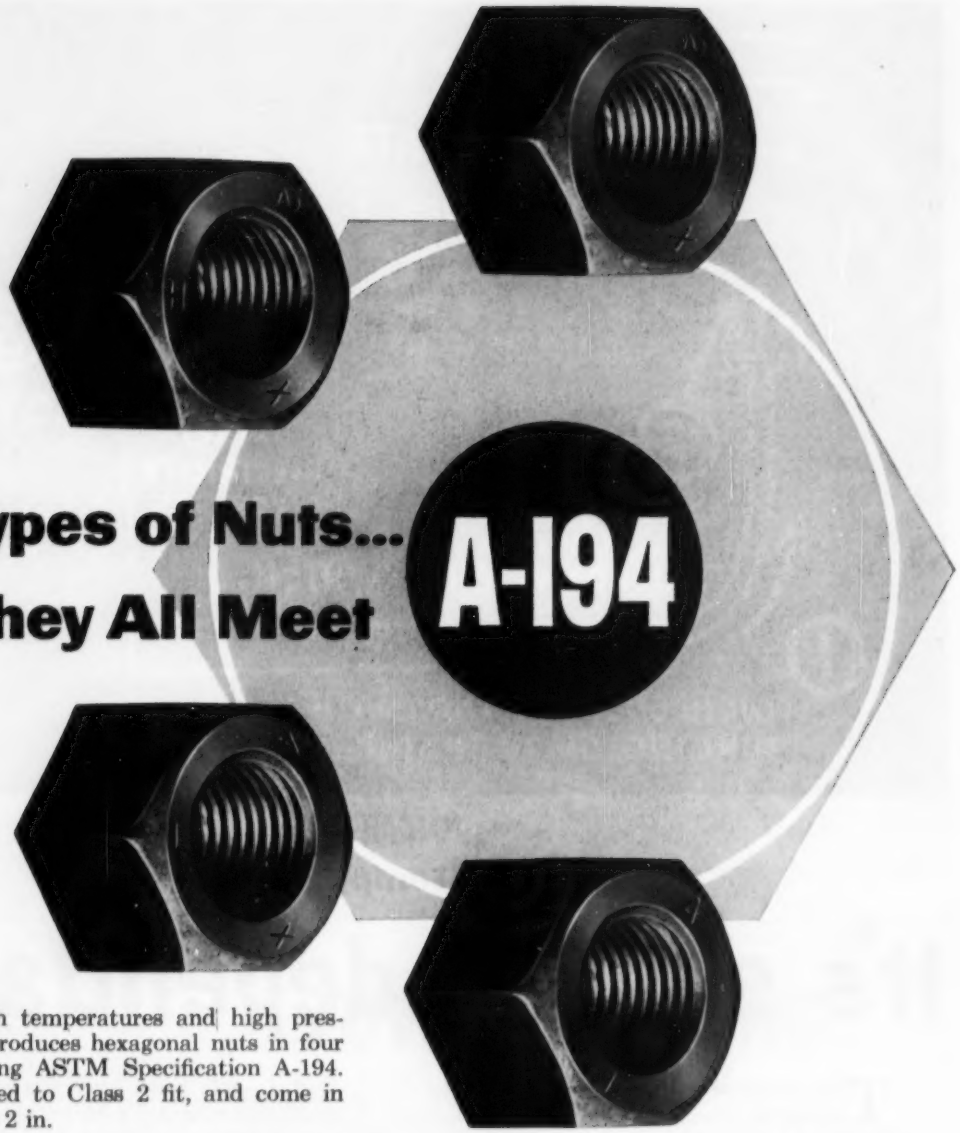

Four Types of Nuts... And They All Meet A-194

For service at high temperatures and high pressures, Bethlehem produces hexagonal nuts in four grades, each meeting ASTM Specification A-194. The nuts are tapped to Class 2 fit, and come in sizes from ⅜ in. to 2 in.

GRADE 1 Low-carbon steel. Suitable for non-critical applications; also for use at moderately elevated temperatures. Carbon 0.15 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness 120 min.

GRADE 2 Medium-carbon steel, specially intended for use at moderate temperatures and pressures. Carbon 0.40 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness is 160 min.

GRADE 2H Excellent for high-temperature, high-pressure service because it is quenched and tempered. Carbon 0.40 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness 248 to 352.

GRADE 4 Molybdenum steel, heat-treated. For severe temperature and pressure conditions. Bethlehem Grade 4 nuts are also ideal for sub-zero service, their 4L marking indicating they meet the impact requirements of Spec. A320 for low-temperature bolting. Nut has minimum Charpy impact value of 15 ft-lb down to —150 F. Carbon 0.40 to 0.50, Manganese 0.50 to 0.95, Phosphorous 0.04 max, Sulphur 0.05 max, Silicon 0.15 min, Molybdenum 0.20 min. Brinell hardness 248 to 352.

If you would like to have additional information, just drop a line to the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
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BETHLEHEM STEEL

BETHLEHEM STEEL

Who's Building. . .

Refinery. Until other processing units are completed, the crude unit's output will be held in storage for further processing, except for a limited quantity of marketable fuel oil.

Sanyo Chemical Company, Mitsubishi Petro-Chemical Company, and **Yokohama Rubber Manufacing Company** each submitted to the Japanese Minister of Trade, plans for building separate synthetic rubber plants, output of which would amount to 15,000 tons each by 1960. The Trade Ministry, however, has expressed doubts that such small plants operating independently could be put on a paying basis, and has therefore submitted a counter-proposal.

The Trade Ministry suggests that the three firms join forces to initiate synthetic rubber production, and has asked the Finance Ministry for an appropriation to finance a "semi-official" company. The amount needed to launch such a plan is $29,095,000, of which $3,525,000 would be covered by direct fiscal government investment, and $18,331,000 by low cost loan from Japan Development Bank.

Further plans call for private companies to put up $3,525,000 while commercial banks supply loans totaling $3,713,000.

It is expected that the amalgamated company would lose money until 1960, but that a profit would be made from 1961 onwards. At that stage, the company might be put into the hands of private industry.

Jordan Government, it is reported, will shortly send a mission to visit Syria, Lebanon, Egypt, Saudi Arabia, and Kuwait to seek Arab capital for construction of a refinery in Jordan.

E. I. du Pont de Nemours and Company, Inc., has announced that the cancellation of their plan to add a sodium and chlorinated solvents unit at its Antioch Works will in no way affect the tetraethyl lead and "Freon" refrigerants phase of this operation.

Shell Austria A.G. has recently placed on stream a new lube oil blending plant at Wein-Simmering. The plant has three main units; a grease manufacturing plant, an oil blending plant, and a unit for the manufacture of high-grade special oil products and chemical materials.

Standard Oil Company (Indiana) will start construction early in 1957 on a new Ultraforming unit to increase its production of high-octane gasoline. It will process more than 6,000 barrels of naphtha a day. Foster Wheeler Corporation of New York has been awarded construction of the Ultraformer. The unit is expected to start operating January 1, 1958.

The Neodesha refinery at the same time will add about 175,000 pounds an hour of steam generating capacity. Other facilities for cooling water, including a new cooling tower and water treating equipment, will also be installed.

Four additional storage tanks are to be constructed in the refinery area.

Sunray Mid-Continent Oil Company will build and operate a new gaso-

THIS IS THE STORY of three men and a VALVE. Joe, a chemical engineer, needed valves that could handle tough corrosives. Bill, a refining engineer was looking for valves that gave a positive shut-off. Tom, working for a large industrial firm, needed valves that sealed both upstream and downstream. All three solved their problems by specifying Hamer Visible Wedge Valves. These remarkable valves combine the double sealing action of precision metal-to-metal fit augmented by dependable seal rings. The wedges are trimmed with nickel, while seats are trimmed with stainless steel to withstand the roughest corrosive conditions. The full-view wedges are handwheel operated --can't blow out or drop on a toe. The wedges pivot so no lifting is necessary.

So if your plans require long service, sure-seal shut-off valves, by all means specify

HAMER VISIBLE WEDGE VALVES.

P.S. For descriptive literature, write:

Hamer **VALVES, INC.**

2919 Gardenia Ave., Long Beach 6, California
Representatives Throughout the World.

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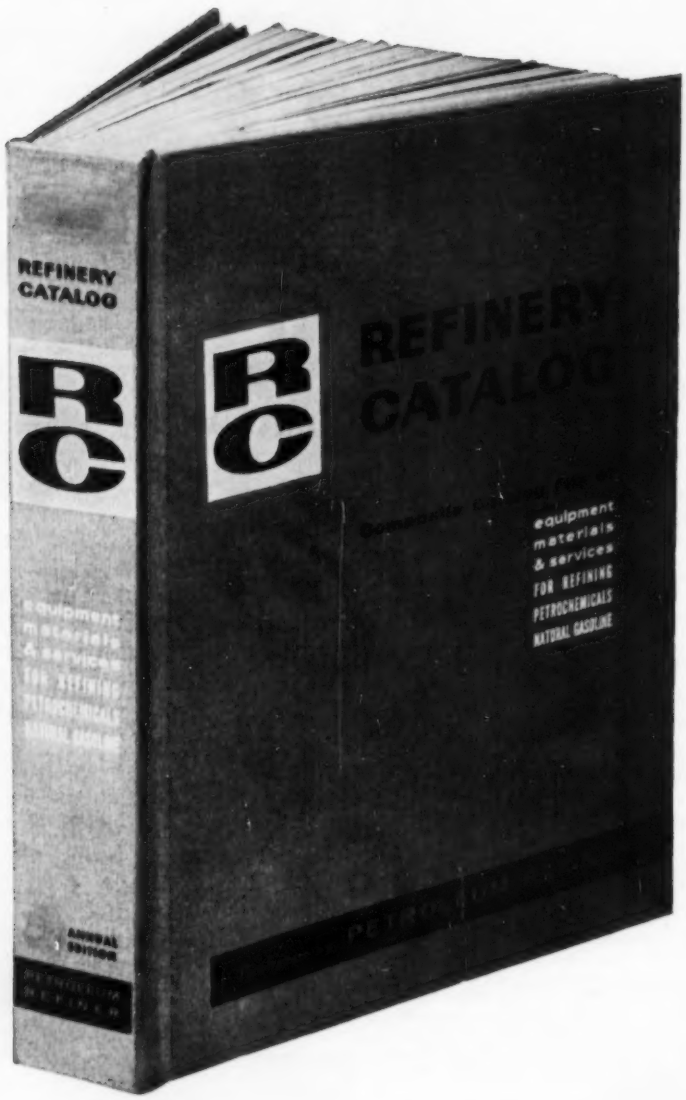
IN "NEW DRESS"

Here's how the REFINERY CATALOG's 1956 Edition appears, with new cover design featuring a large "RC" for easy identification.



When you have to make fast, accurate buying or specifying decisions, use the REFINERY CATALOG. It is the Refining Industry's universal equipment guide . . . containing the information you need for adequate comparison on hundreds of different types of products and services.

In the new (23rd) Edition, you'll find catalog data from more than 270 companies serving this industry, authoritative specifications and data, local sources of supply . . . and a convenient index of manufacturers, equipment and services.

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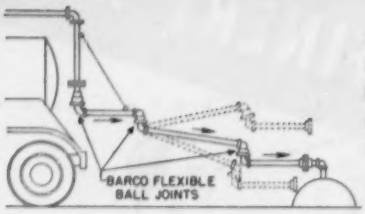
For SAFETY and Lower Costs in Handling Sulfuric Acid



The accompanying sketch shows how three Barco Ball Joints in unloading (or loading) line provide complete flexibility for making connections in any position. Note how line folds neatly on back of truck when not in use (photo below).

Barco Flexible Ball Joints Replace Hose

Two near-accidents with hose blowing out some time ago, while handling sulfuric acid with 30 psi air pressure, caused Rogers Cartage Co. of Chicago to change to Barco Flexible Ball Joints (with malleable iron casing and stainless steel ball) in loading lines on some 15 big trucks serving many chemical, petroleum, steel, and other customers in the Midwest area. Since making the change, Mr. Jack Kidder, Rogers Safety Manager reports that there have been no failures and little or no maintenance on the joints. Cost for frequent hose replacement has been eliminated. *Inquiries are invited, address Barco. Ask for Catalog 215B.*

ADVANTAGES

NO METAL-TO-METAL CONTACT BETWEEN MOVING PARTS — No ball bearings to corrode.

CHEMICALLY INERT GASKETS — No. 11-CT for corrosive service. Suitable for many liquid chemicals.

PRESSURE-SAFE! FIRE-PROOF! — Unequalled for SAFETY, DURABILITY, ECONOMY.

CHOICE OF STYLES — Angle or straight. Sizes ¼" to 6". Available in choice of metals, including stainless steel and special alloys.

APPROVED — By leading chemical manufacturers and trucking associations.

BARCO

BARCO
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542-M HOUGH STREET
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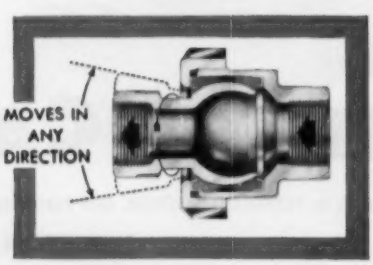


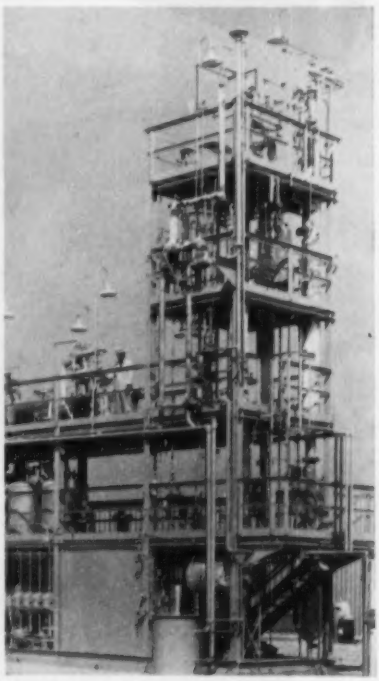
Who's Building . . .

line products field plant near Carney, Okla.

The plant will process 17½ million cubic feet of natural gas a day, and will produce propane, butane and natural gasoline which will add approximately 2,000,000 barrels of products to Sunray's reserves over a long term.

Tuloma Builders of Tulsa will construct the prefabricated plant. Start of operations is scheduled for April 1, 1957.

Travancore, Ltd., plans to increase its ammonia capacity to 80 tons a day at its Alwayle, India plant. Also planned is capacity increase for ammonium sulphate production and initial manufacture of ammonium phosphate. Cost of the entire project will be about $4.1-million.



Proving ground for a new manufacturing process, this pilot plant at the new Richfield Oil Corporation Anaheim Research Center produces phthalic acid. The plant is part of the recently completed Richfield research and development laboratory which held an open house October 23-25.

Canadian Bechtel, Ltd., Toronto, has been awarded a contract to build Imperial Oil Company's recently announced $25-million petrochemical plant at Sarnia.

Months of engineering work, coordinated by Imperial's engineering divisions will be needed before actual construction gets underway in the spring of 1957. The plant is expected to be completed in the spring of 1958.

Celanese Corporation of America has started construction of a new polyol production unit at its chemcel plant in Bishop, Texas. The new facility, reports that it will utilize special aldoling processes developed by Celanese and will greatly expand capacity for polyol and aldol production which began a year ago with the

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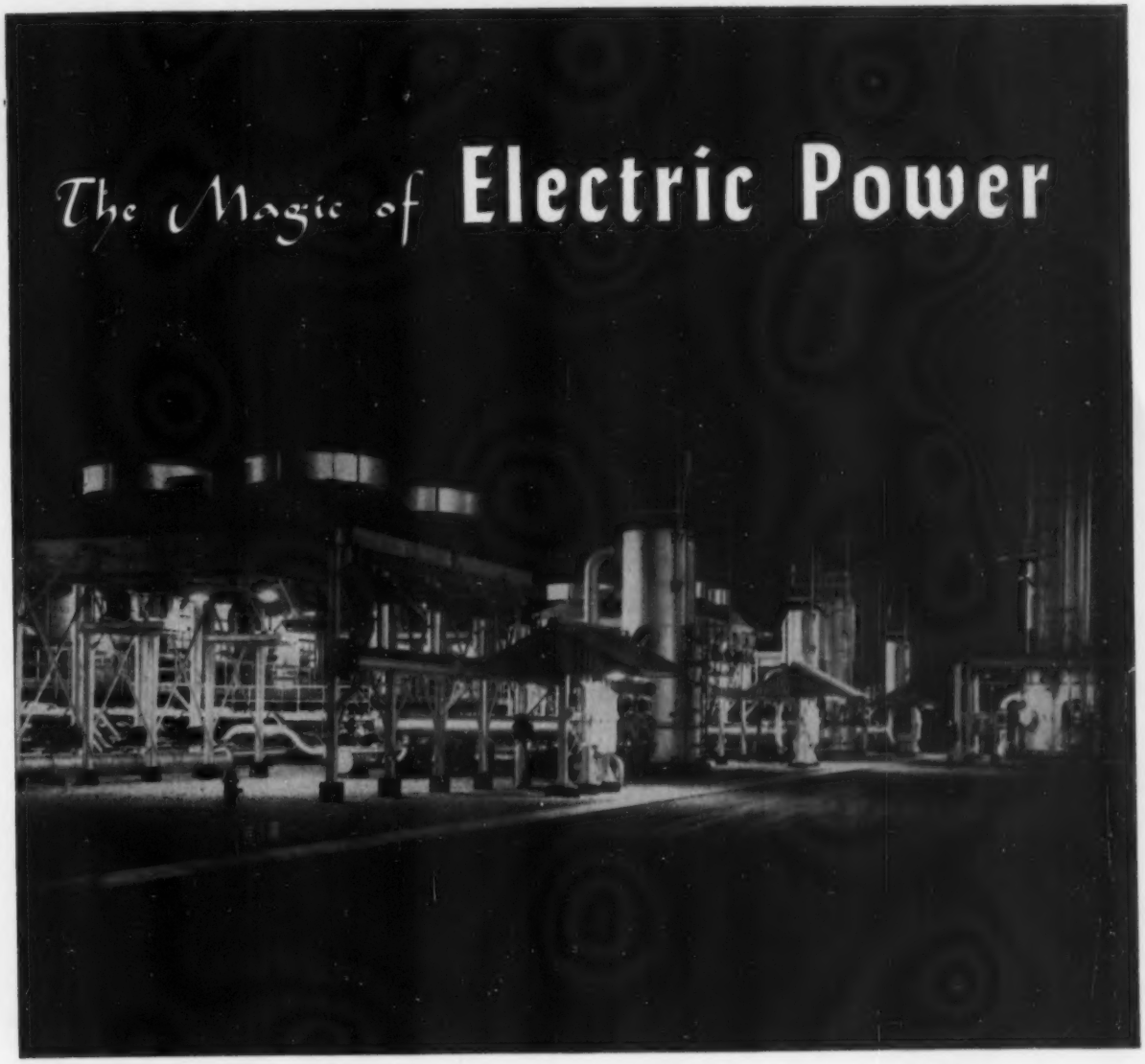
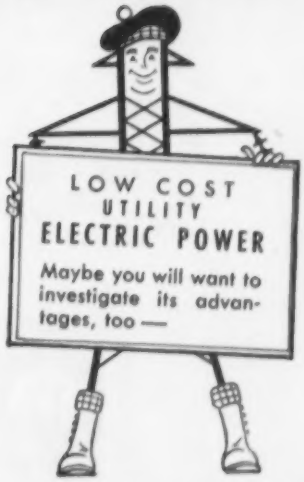
The Magic of Electric Power



Service... Dependable Service

Next to a captivating sunset nothing has such a magical appearance as a giant refinery flooded by the grandeur of electric light on a pitch dark night.

Spectators view it with unceasing awe — Businessmen view it as a well-lighted, efficiently powered investment. Over 72 per cent of this nation's refineries utilize dependable purchased Electric Power. More cost conscious men are specifying it every year.



WRITE PETROLEUM ELECTRIC POWER ASSOCIATION, P. O. BOX 2771, DALLAS, TEXAS, OR CALL THE SALES ENGINEER OF YOUR LOCAL UTILITY ELECTRIC POWER COMPANY—NOW

For more data on advertised products, use Readers' Service Cards, last page.

Get fouled-up drill rigs back on duty—*fast*... with

Oakite Chemical Cleaning

Take, for instance, a bottom-hole pump brought in from the field for replacement... outside mucked up, insides chocked with gyp.

Useless? Not if you know Oakite. A half-hour at most, and this pump can go back to work! Here's how.

A short soak in a recommended Oakite degreasing solution (Oakite 19 or 24, depending on soil), followed by pressure rinse, and everything comes off the outside. Grease, oil, paraffin, mud, rust—gone. Next, immerse in a descaling solution of Oakite 32, and now the insides are clean of all accumulated gyp and lime deposits. Rinse, then neutralize by dipping in the Oakite 19 or 24 solution. Finish by rust-proofing pump with Oakite Special Protective Oil . . . and it's ready to go.

This is just one example, out of dozens of reconditioning jobs on field equipment, where Oakite methods give you maintenance cleaning at its fastest and easiest. Call your local Oakite Technical Service Representative, or write for free booklet, "*What Petroleum Men Should Know to Simplify Cleaning*," to Oakite Products, Inc., 50D Rector Street, New York 6, N. Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Who's Building...

start-up of a semi-works unit.

The new commercial unit is expected to be completed and producing by the last quarter of 1957.

Esso Standard Oil, S. A., Caribbean refining and marketing affiliate of Standard Oil Company (New Jersey), has signed a contract to modernize and expand its Belot refinery in Havana.

The work will involve the addition of crude distillation facilities, fluid cat cracking, catalytic polymerization, hydrofining, powerforming and related facilities for the production of gasoline, diesel oil, kerosene and fuel oil.

When work is completed, the refinery's capacity will be increased from 8,500 to 35,000 barrels a day.

Humble Oil & Refining Company will construct a benzene unit at its Baytown refinery. The unit, which will be one of the largest of its type, will be designed to produce about 24,000,000 gallons of benzene annually. Construction is scheduled to start about the second quarter of next year with completion slated for late 1957 or early 1958.

Blaw-Knox Company, Chemical Plants Division, has been awarded a contract to design and construct a synthetic rubber plant for The International Synthetic Rubber Company, Ltd., near Fawley, England. This is a newly formed company organized by Dunlop Rubber Company, Ltd., The Goodyear Tyre & Rubber Co. (Great Britain) Ltd., The Firestone Tyre & Rubber Co., and Michelin Tyre Co., Ltd.

The first synthetic rubber plant to be built in Great Britain, the new facility will have a capacity of 50,000 long tons of GR-S a year. It will be located adjacent to the petroleum refinery of Esso Petroleum Company, Ltd., which will supply the butadiene, one of the major raw materials going into the product.

British Hydrocarbon Chemicals Ltd., jointly owned by The Distillers Company, Ltd. and British Petroleum Company, Ltd., has authorized the design and construction at Grangemouth, Scotland, of a 25,000,000 pound per year polyethylene plant using Phillips Petroleum Company's new catalytic process for making polyethylene and other polyolefin plastics.

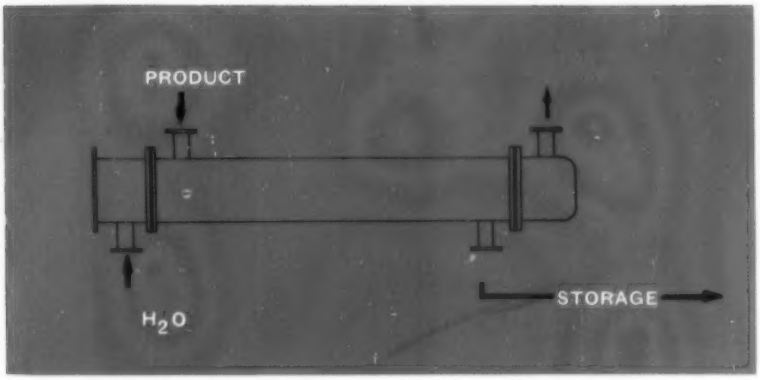
Dow Chemical Company will build a plant to make 12 to 14 million pounds a year of Zefran staple fiber. This decision came after a five year period of research and development in the field of synthetic fibers. Plant construction is expected to begin some time this fall.

American Synthetic Rubber Company, Louisville, Ky., has commenced construction on a $3,000,000 addition to its manufacturing plant. Designed, engineered, and constructed by the Southwest Division, Walter Kidde Constructors, Inc., the addition will increase existing facilities at the Louisville plant by 50 percent. Completion is forecast for January, 1957.

Three major structures constitute the expansion project; a reactor building, a three-story recovery building, and a finishing building. The reactor building will

For more data on advertised products, use Readers' Service Cards, last page.

Trufin Type S/T Boosts Cooler Capacity 50%



Secret? Integral Design

WHY TRUFIN'S EXTENDED SURFACE BOOSTS HEAT TRANSFER PERFORMANCE

Wolverine Trufin Type S/T is an extended surface condenser tube. Its fins are actually extruded from the tube wall. The advantages inherent in this integral design are many.

In the first place a ¾ inch Type S/T condenser tube has an external to internal surface ratio of approximately 3½ to 1. It has approximately 2½ times as much outside surface as the plain tube it is designed to replace. It is this amazing increase in effective heat transfer surface which permits Trufin Type S/T to achieve such outstanding heat transfer performance records. And by the way that S/T is short for "shell" and "tube".

Because the fin is part of the tube it also eliminates the possibility of a loss in "Fin Joint Efficiency" regardless of temperature, thermal shock or vibration. Exhaustive pilot plant research reveals that type S/T resists fouling for longer periods than does prime surface tube.

Trufin Type S/T is available in a wide range of sizes and alloys in copper, aluminum and electric-welded steel. It can be fabricated as readily as plain tube with its integral fins giving added support on bends.

Free Book Gives Design Information

The "Trufin Opportunity Book" is available without charge from Wolverine Tube, exclusive manufacturers of Wolverine Trufin Type S/T. Compiled from actual case histories, this book contains valuable design information for operators of shell and tube heat exchange equipment.

By Ernest Dodd

It's nice . . . real nice . . . when you can solve a tough problem and get yourself covered with glory—both at the same time. This is what happened to a group of refinery engineers I talked to recently, while on a field trip in the east.

These boys were faced with boosting throughput from an alcohol cooler. Here's the way in which they handled the situation.

Instead of building a completely new unit, these engineers retubed the existing prime surface tubed cooler with Wolverine Trufin Type S/T electric-welded steel condenser tube. The results were immediate—and highly gratifying.

Capacity literally zoomed—jumped a full 50%. This in itself was enough to win them a pat on the back—but there was more yet to come. In addition to increased capacity, refinery management realized considerable savings in time, materials and labor.

Retubing with Trufin Type S/T, for example, did away with the cost of tearing down old equipment and designing and installing a new and larger prime surface unit. Also eliminated was the necessity for stronger supporting members which would have been required to support a heavier unit designed around prime surface tube.

Small wonder, indeed, that management was highly pleased. The moral to this story is plain. If you want to put yourself in solid with the brass just specify Wolverine Trufin Type S/T when retubing existing equipment or having new ones designed.

DIVISIONS OF CALUMET & HECLA, INC.

CALUMET DIVISION
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO., LTD.
FOREST INDUSTRIES DIVISION
GOODMAN LUMBER CO.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.
1437 CENTRAL AVENUE, DETROIT 9, MICHIGAN
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario

Cut Condenser Tube Handling Costs

Here's a way to reduce tube handling time and costs, speed up equipment assembly, and eliminate the transportation difficulties present when handling long length condenser tubes.

Wolverine U-Bend condenser tubes are designed to achieve all these points—and more besides. Here's how:

Working to your specifications Wolverine prefabricates U-Bend condenser tubes and packages them on disposable pallets—*in the exact order of installation.*

All you have to do is feed the tubes directly from the pallet into the unit. Think of the convenience this can bring to your operation particularly when handling tubes over 30 feet in length. In addition, Wolverine U-Bends also cut rolling-in operations in half, eliminate one tube sheet and make floating head problems a thing of the past.

Wolverine U-Bends are available in a wide range of sizes and alloys in copper, aluminum and electric-welded steel. They may be specified in prime surface form or with integral fins (Wolverine Trufin) for increased heat transfer surface.

Next time you place an order for condenser tubes—specify Wolverine U-Bends—reap the immediate benefits these prefabricated tubes can give. For complete information write for Wolverine's Condenser Tube Catalog.

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& EQUIPMENT CO. LTD.
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Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

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SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPT., 11 E. 40TH ST., NEW YORK 16, N.Y.

5501—5511W60

Who's Building. . .

contain twelve new reactors for processing cold rubber, three blow-down tanks and an off-grade latex tank, together with necessary charging equipment and additive facilities. Included is reconversion of eight existing cold process reactors to hot process. In the finishing building, three 40,000-gallon tanks will be provided for blending latex.

Diamond Alkali Company, Cleveland, Ohio, has announced plans to proceed with designing and engineering of a multi-million-dollar facility for manufacturing acetylene. The proposed plant will be located at Diamond's Deer Park Plant at Houston, Texas.

Engineering studies for the project, already under way, are expected to be completed by April, 1957, with construction slated to start in the fall the same year.

Akron Gasoline Company is building a $500,000 gas processing plant at Akron, Colo. Prengle, Dukler & Crump, Houston, is doing the engineering for the plant which is slated for completion November of this year.

Phillips Petroleum Company has named Procon Incorporated, Des Plaines, Ill., as contractor for construction of a fluid catalytic cracking unit at its Great Falls, Mont., refinery.

The unit is planned to handle 3,000 bbls. of combined feed per day. Construction field work will begin in November, with completion of the project scheduled for spring.

The Dow Chemical Company expects to have a near-future investment of more than $50,000,000 at its Louisiana Division at Plaquemine. The proposed investment reflects plans and estimates that have been firmed-up since the original announcement of plans for a Louisiana manufacturing operation was made last February. At that time the investment was estimated at $20,000,000.

Canadian Oil Companies, Ltd., has awarded the contract for the $3,000,000 petrochemical plant at its Sarnia refinery to The Fluor Corporation of Canada, Ltd.

The contract calls for the engineering and erection of a Udex plant having a design capacity of 3,650 barrels a day, and a 4,400 barrels per day Platforming unit. Construction will commence this fall and completion of the new plant is scheduled for next summer.

Commercial Solvents Corporation will substantially expand its methol purification facilities at Sterlington, La. The company has received a state tax exemption expenditures of $5,133,400 which includes the cost of the methanol unit, and other expansion.

J. M. Huber Corporation, has announced that Huber manufacturing processes will be utilized in the design of the new carbon black plant to be erected near Melbourne, Australia. The plant will be owned jointly by United Carbon Company, Inc. and Shell Petroleum Co., and will produce standard grades of carbon black, matching the corresponding American types.

How to put the Indian Sign on your high temperature pumping problems

When you pump heat-transfer liquids at 600° F. or above, you run into some pretty tough problems. You have to keep the seal cool enough to prevent the heat from damaging it. Yet, you have to do this without cooling the liquid in the pump. The pump shaft must be big enough to avoid deflections that cause undue wear on seal and shaft sleeve. And the stuffing box better not leak—because heat transfer liquids are mighty expensive.

Dean Brothers put "the Indian sign" on every one of these toughies in their standard centrifugal process pumps. They did it with a simple, standard, readily-available mechanical seal. And they did it without the use of gimmicks or expensive auxiliary pressurizing equipment for the cooling liquid.

Engineering like this—plus mechanical reliability usually found only in costly, individually engineered pumps—means lowest cost in the long run—when operation, maintenance and replacement costs are fully considered.

For full information about Dean Brothers complete line of standard, heavy duty, centrifugal process pumps, Series 10, Series 20 and Series 30—to 7,000 gallons per minute capacity, send for Circular No. 184A.

INTERCHANGEABILITY OF PARTS MEANS MORE PUMP FOR YOUR MONEY

The eleven pumps in Dean Brothers Series 10 standard centrifugal pumps have a range of application that covers fully 90% of all process pumping applications. They're all built from the same standard parts with the exception of the Casing, Impeller and Suction Nozzle which determine each pump's capacity. For high temperature services the cradle housing is integrally water jacketed; for temperatures up to 350° F., it is not. Otherwise, all parts are completely interchangeable. Even the stuffing box that houses the mechanical seal will also accommodate conventional packing—another neat bit of standardization that eliminates special pumps for high temperature services.

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS 7, INDIANA

Centrifugal and Reciprocating Pumps • Since 1869

For more data on advertised products, use Readers' Service Cards, last page.

Are Your 'Communications' Showing?

The fierce championship by employes for a company's cause is not a dead pigeon if the right people do the right job of communicating.

William S. Wilcox
Newton Square, Penn.

A VICE-PRESIDENT of one of America's oldest companies had just finished an hour-long employe communications program. The session included usual bulletins, posters, letters to the home, group discussions—all dressed up with the showmanship touch of stage properties and visual aids.

After the usual plaudits were extended, the meeting plunged into serious business as one clay-footed soul, possibly surfeited with the mental punishment of the subject matter, burst out with:

"Sir, the program surely has visual appeal. What is it costing you?"

Taken slightly aback, the executive replied, "Approximately $75,000 a year out-of-pocket money. We believe it is a good investment."

"That seems like quite a bit of money for the total number of employes your company has, sir. Could you say what attitudes and actions of your employes compelled you to undertake the program—and now that you have carried it on for two years, can you put your finger on any changes in employe actions and attitudes which in your view justifies continuing to spend $75,000 each year?"

The vice president exploded: "Well I'll be——. I don't know. But, I'm going to take the next couple of days to find out."

There is no way of knowing if that was the end of the program also, and perhaps the beginning of a more productive use of $75,000. Moral: Let those who are promoting formal employe communications programs look inward. Let them search for the answer to the question—*who is communicating about what with whom?*

Management Is Responsible—The employe audience is a vast one. Take the petroleum industry. Of the 100 largest industrial employers in this country, 11 concerns are petroleum companies. These 11 petroleum companies have 527,000 employes—and each employe has many contacts.

The moral in all of these is that management should examine very carefully employe information projects which extend beyond the competence and resources of knowledge within a company—and that responsible members of managements also, through their publicized activities off the job, communicate with employes.

It is not startling to any but the people involved when members of management and members of the rank and file employes, including union members communicate like other people. It's a rare representative of management who is so self-contained that he does not respond visibly to the appearance of ill will—and no employe is so insensitive to the things around him that he does not react to those irritants that sting him as well as to attitudes of others that lift him in spirit and confidences.

When an employe relations crisis builds up, it reaches boiling point usually because somebody has been caught with their communications up in the air. Then everybody looks for the culprit. Management goes into a huddle—employes go into huddles. Out of the huddles come the campaigns—not necessarily to find the causes but often to force the issues to a conclusion favorable to which ever side the huddler is on. On their part the communicators for management are rarely ignorant of the coming of the storm. They develop programs to deal with what they interpret to be the problem. Perhaps the programs do bring a temporary relief but if they fail to eliminate the causes, the trouble starts all over again.

For example, in a recent ten-year period, some 25,000 formal grievances were filed in a single company of a major industry. In capsule form, a bit more than 28 formal grievances per 100 employes were processed over the ten-year period—about 1000 of them went on to arbitration.

In a community of 100 households, if 28 of the neighbors went to law to settle their differences over a ten-year period, it would seem like a lot of "a fussin' - n - feudin'." It would seem that the main communications between management and employes were being channeled through a grievance procedure and the great number of continuing grievances were symptoms of underlying causes.

Yet the company publicly proclaimed the efficacy of its grievance procedure as a means of stabilizing labor-management relations. A grievance procedure is only a channel for certain types of employe-to-management communication. The grievances represent many symptoms from which management may diagnose the cause.

Competition From Unions—Unions are knee-deep in the employe communications field—as a direct competitor with management. All the

the ABILITY TO SERVE

The Warren **RESOURCES** . . . of production, of transportation . . . of storage . . . plus Warren **EXPERIENCE** as a specialist in its field . . . form a completely dependable **ABILITY** team.

That is why the Light Hydrocarbons Industry . . . natural gasoline and LP-Gas . . . **NATURALLY** looks to Warren for satisfying **SERVICE.**

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As Management Sees It . . .

Grievance procedures should only be channels for *certain types* of employe-to-management communications. Yet, within ten years one company has received . . .

. . . 25,000 formal grievances, averaging . . .

. . . 28 grievances per 100 employes, and . . .

. . . 1000 of the grievance went on to arbitration! Something is drastically wrong when a company's main communications with employes seems to stem from formal grievances. In a community of 100 households, if 28 of the neighbors went to law to settle their differences, it would seem like a ridiculous amount of "fussin' and feudin'." The same is true in industry.

pious words and lifting of eyebrows in protestation of such a statement—all the ringing speeches on "democracy in action" will not decrease the distance across the bargaining table.

The competition whirls around the orbit of leadership of employes. At one time, management had the leadership and exercised it—too badly too often to control it in the minds of influential groups at Washington. The Wagner Labor Relations Act effectually nullified it for a long time—for good managements and bad alike. The national administration of that period knowingly and deliberately injected and promoted the competition within the employe-management relations area just as they did with other areas of our nation's economic life.

In recent years only, has it become normal again for management to publicly take a stand for leadership in communications with employes, without risking the penalty of being in violation of the law. However, no fine distinction has ever hampered the efforts of the unions in their competitive work.

A historic competitive issue is the union shop. One official publication of an international union in a recent issue advertises a new AFL-CIO education film "Injustice on Trial," featuring an all AFL-CIO union cast. The screen play revolves around a court room "trial" of "right-to-work" legislation. The same issue contains a quarter page article on "Security Program Can Cover Up Spying On Unions, Labor Says."

How Management Can Compete—How does management respond to such competitive projects? A search of employe publications of the companies most likely to be affected by the competition of the specific publication cited above, failed to turn up even the remotest clue that any competitive issues were in existence let alone active competitive campaigns.

The most recent issue of the official employe publications of the major units of the specific industry contain a great amount of employe doings, and company plans, but not word one to offset the competitive drive of the union publication. Nothing to explain in rebuttal the position the companies take on the protection of the security of the employe's job.

However, this iron curtain does not hang throughout all of industry. Some time ago, during a period of labor negotiations, it became plain to the communicators and negotiators of a large electrical manufacturer that the complete story of the position taken by the company at the bargaining table was not being told to the union members by the union officials—and a strike vote was looming. Thereafter a transcript of the negotiating discussions in toto was made by the company each night after the conclusion of the day's bargaining sessions. Copies were placed available to every employe each morning.

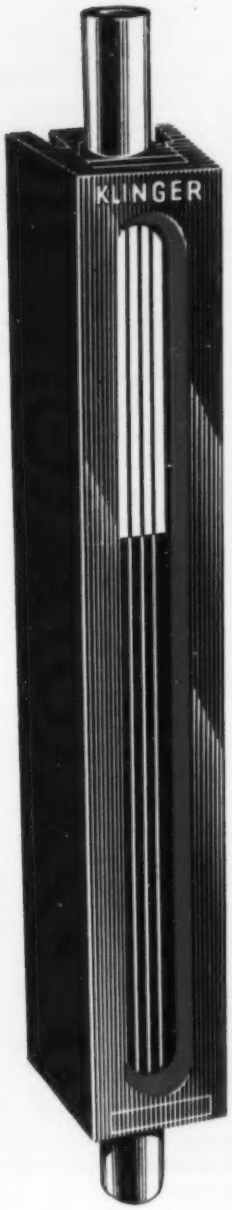
The employe no longer looked at only the filtered color. He had the facts. Eventually the union leaders called a strike vote. It failed to pass. No one can say the savings to employes and the company of this forthright communication project but a recently ended strike in the same industry is reported to have cost a company $300 million in orders alone.

"To the President"—There are other signs that employers may in time strike off the fetters that bind them to routine texts. Here and there a management does, in effect, say to the editor of an employe publication, "write and edit the paper as you believe it to be in the best interest of the employes and this company. On matters of policy statements, check with the responsible management—on matters of employe interest and concern, use your own judgement." No over-riding editorial board to weigh a word or delete an inconvenience.

One very effective publication of a company that has enjoyed tranquil employe relations for several decades has a "To The President Column." Employes address their letters through the editor—their questions are frank and they get a frank answer. There are no restrictions on the subject matter, and some topics burn holes in the paper.

Another company is experimenting with the publication of an employe paper by turning its contents and its publishing over completely to an employe editorial group elected by the employes—without strings or management censorship. These may be only straws in the wind, but in all the experience of employe-management relations, it is being proven continually that responsibility given to employes begets responsible attitudes from them. This is being communicated to managements all over the country throughout many industries in the growth and influence of the Credit Union movement as one example.

Keep Abreast of Employe Actions—Perhaps not too well recog-



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The "K" Type Reflex Level Gage has the following outstanding advantages:—

Single row of tightening bolts

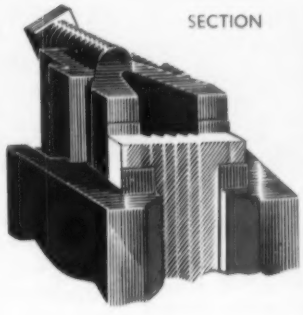
Body free from distortion

Glass easily removed

Gage body turnable, free to expand, and easily removed.

The "K" Type Gage is made in a wide variety of sizes and any number of bodies can be combined to provide level indicators of any length.

Write to your Klinger agent for descriptive leaflets and literature.



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G.19/56/G.

Employe Communications are strictly a dollars and cents matter in any company's operation. Following are the costly results when poor communications exist:

- **Voluntary quits.**
- **Discharge for cause.**
- **Disciplinary actions.**
- **Short time absences.**
- **Grievances as to cause.**
- **Tardiness.**
- **Personal injuries.**

nized is the fact that employes are communicating with management daily, every hour on the hour so to speak. When an employe quits he has communicated something to management—he prefers not to work there any more. The reason why is something vital to him and probably a lot of other employes. Getting at the reason is not something to pass off with a shrug.

A reference has already been made to employe grievances—the importance of knowing what the actual gripe is should not be underestimated. Many other employes are aware of it and can be effected by it.

In sum total, the actions of individual employes are more significant than their words or the statements of their union leaders. All of these actions are communications to management. To know their actions, is to know employes, but how many managements require a statistical summary periodically of the events through which employes communicate their responses to the circumstances of their employment? These are the circumstances which influence voluntary cooperation and thereby the production of employes.

Results of Poor Communications—Not to know what these actions are and where they are occurring in an organization is like running a railroad train with no track signals. One should never forget that people do what they want to do if they can. Employes communicate their convictions by acting when personal circumstances permit action.

To give an example, the manager of a petroleum bulk plant was advised that the unorganized employes were planning to affiliate with a national union. He discounted the advice completely.

In his own words, he had personally enjoyed evenings out with the whole group—knew each one and was sure on the basis of this acquaintance that if such a plan to organize was underway, he would have known about it directly. The reasons for organizing—the arbitrary actions of the plant superintendent—was completely beyond belief, in the manager's mind. On a morning ten days later, the manager arrived at his office and was presented with a union contract for signature. What the employes had said to the manager was denied by their action.

Possibly a knowledge of their actions on the job previously might have revealed the shadows cast before the coming event.

Evidently the atmosphere created by the social activities lulled the manager into accepting appearances for reality. The ever present apprehension of authority by employes is not easily dispelled. It is not what executives and supervisors say about freedom to talk that is important—it is what they do to make it easy and how they respond to people who try. A lot of profitable communications expire at the threshold of a manager's door.

Not a Swivel-Chair Job—Several weeks ago a want ad in a great metropolitan daily brought to light for a fresh analysis, the information vacuum generated by all-out exponents of staff industrial relations work—those communicators who interpret their industrial relations responsibilities "as purely a staff or advisory function—nor is its main function to represent employe viewpoints to management." The ad read:

> "Wanted: Industrial Counselor. Interesting assignment for mature, stable and personable individual. Must have industrial experience, *handling grievances, personnel problems, administering collective bargaining agreements*—must be able to *maintain good working relationship with all levels of supervision*. Have capacity to inspire confidence so that others come to seek aid, counsel, *guidance and support*."

No slide rule wage and salary administrator this, no legerdermain of tests, no necromancer of executive development required, just someone who can see people as people—face to face—talking and listening—communicating. Shades of Clarence Hicks, reputed father of Industrial Relations in this country, who out of 50 years' experience in communicating with employes and managers proclaimed a facility now long fallen into sterile disuse.

"Industrial Relations is not an office or swivel chair profession. Frequent personal contacts are essential—a sacred obligation to act as an advocate for the employes."

Don G. Mitchell, chairman of the board, Sylvania Electric Products, Inc., sums it up as, "the first thing that top management expects of personnel administration is understanding and feeling for people. Personnel administration is expected to provide a two way communications system. Keeping track of individual people is the big job of tomorrow."

If the unions demand employe communications facilities and contacts for the stewards, isn't it reasonable for a management also to require such a real and obvious return from the money it allots to its representatives who specialize in employe relations? All that employe relations people need is to take a bit of time off from developing mass programs and refresh their intelligence now and then in contacts with rank and file employes—the source of knowledge and understanding of employes as people.

Employe communications can be personal, direct and effective without lace on its drawers if management demands it. ##

Cameron Sales Engineer, W. E. McDonald, demonstrates Hycar-coated seat.

DOUBLE LPG SEAL with Cameron Lift-Plug Valves

A renewable Hycar rubber-coated seat does the trick. The remarkable Cameron Non-Lubricated Lift-Plug Valve seals in both directions with smooth, sure, positive action. This super-tight seal keeps products in place—prevents trouble. One valve (with telltale needle valve in body) replaces two or more ordinary valves which only seal upstream or downstream.

Non-Lubricated means no contamination of line products, no fouling of delicate metering equipment — best of all non-lubricated means no maintenance. Simply set it and forget it.

The seat of the Cameron Non-Lubricated Lift-Plug Valve is separate from and not attached to the body. Body deflections do not affect mating surfaces of plug and seat. Friction is eliminated because the plug is lifted from the seat before rotating — actually never touches the seat except when completely open or closed. Plug and seat may be easily and inexpensively replaced without removing the valve from the line.

As in the case of these LPG Valves with Hycar coated seats, other special materials may be used for special services. If it's a difficult duty — acid, molten metal or the elusive LPG's, Cameron Lift-Plugs are already saving time and money for someone. It could be you.

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Continued from Page 119

probably will be built within a few years.

There has been some speculation as to the possibility of finding some much more efficient shielding material or combination to minimize this problem. Shielding ability is, however, essentially a property of the atom; and by now every available element has been tested. It is understood that the results confirm the prior opinion of the physicists that no major improvement can be anticipated from new shielding materials.

Other Automotive Power—In discussing the impact of atomic energy on the automobile business, we can rule out engines using atomic fuel; but there are other possibilities to be considered. Might not cheap electricity from atomic power plants be used to charge some new kind of highly efficient storage batteries for electric automobiles?

In the first place, even if atomic power plants do become commercially competitive in from 10 to 25 years, there is very little likelihood that the power will be substantially cheaper than at present; in the second place, further radical improvements in storage batteries for automotive power do not appear to be in sight, despite many years of research. Furthermore, even solving these problems would probably not affect the gasoline business very much.

The electric car lost out once in the competition with the gasoline car when gasoline engines were far less efficient and reliable and power requirements far lower. Atomic energy seems unlikely to put it back in the race.

There is, of course, the remote possibility of revolutionary new devices being discovered which would convert atomic energy directly to electricity, but this seems highly unlikely. At a conference held three years ago, Dr. Walter H. Zinn said he had seen no such scheme that seemed practical. Here again the low first cost and operating cost of the gasoline engine seem practically certain to hold the business for the oil industry.

Possible Space Heating Competition—After the various transportation uses, the next most important use of oil products is in space heating. Is there any chance that atomic energy will replace our distillate fuels, used mainly in home heating? In this field, the customer comes much closer to shopping for mere Btu's then when he buys gasoline.

Direct use of atomic energy for home or apartment house heating seems to be ruled out by its usual handicaps: The need for heavy shielding, the problem of handling radioactive wastes, and the high cost of the equipment.

The high equipment cost is pointed up by the estimates made in connection with the Army Package Power Reactor, designed to generate 1700 kilowatts. Dr. Lawrence R. Hafstad said the probable cost would be "considerably less than $8 million," and there were some "guesstimates" as low as $5 million. Even this figure, however, would be ten times the cost of an equivalent diesel unit. For generating electric power or for producing heat, atomic energy would seem to be attractive only in locations like northern Greenland, where diesel fuel may cost a dollar a gallon instead of the normal 12 or 13 cents.

In other remote locations, particularly where the climate is not too cold, electricity from either coal or atoms might prove economical for driving heat pumps. These are the devices that take low-level heat from outdoors and convert it to the higher-level heat needed indoors. They can also be reversed to cool homes in the summer. It is possible that, in spite of high first cost, the heat pump will within a few decades become a substantial competitor of the oil industry in certain areas.

Atom to Aid Oil Industry—I have indicated the reasons why I believe that no important phase of the oil business will be adversely affected by atomic energy in the foreseeable future. On the contrary, atomic energy is likely to help us in many direct and indirect ways. For example, the increasing tendency toward decentralization, for both industry and the population generally, is undoubtedly partly due to the atomic bomb threat.

Decentralization means increased travel which will be largely powered by oil, and mainly over roads built with our asphalt. New construction in outlying districts will use oil-powered bulldozers and certain asphalt-based building materials.

The enormously greater power of atomic bombs will cut down bomber fuel requirements in any future wars, but that would mean a welcome reduction of the oil industry's peak load in wartime, and would lessen the need for wartime rationing of our products —even assuming the next war lasted long enough to require it!

The oil industry, as well as others, will also benefit by the new research methods and tools made available by the ability of atomic piles to produce radioactive tracer elements at moderate costs.

Perhaps the ultimate way of getting gasoline will be to start with a solar or atomic power plant. That power could be used to electrolyze water into hydrogen and oxygen. The hydrogen could be used to reduce carbon dioxide from the air to carbon monoxide, and the hydrogen and carbon monoxide could then be combined to make gasoline. However, we might well find that the use of electric storage batteries charged from these sources would be cheaper, though rather too heavy for our present ideas as to cars.

Even earlier might come the use of atomic energy in the processing of oil shale. The Bureau of Mines is reported to have re-estimated the amount of their material available, and now believe Colorado shale could supply the U. S. energy needs for 300 years! Since costs of handling the waste rock are large, atomic energy might well be used to supply heat to decompose the shale—and thus make all of the carbon atoms available for gasoline and other liquid fuels.

Possibilities of Fusion Type Process—There is a rather remote possibility of getting controllable power from the "thermonuclear" or "fusion" type of process in contradistinction to the "fission" type of process. Most of the development work to date has been made on the fission type of process, and it is thus far the only one known to be feasible.

It was, of course, known, even before we learned about fission, that most of the energy of the sun comes from a fundamentally different type of nuclear reaction; namely, the "fusion" of the light element hydrogen into the heavier element helium. This reaction, like that of fission, involves the disappearance of mass and the creation of energy.

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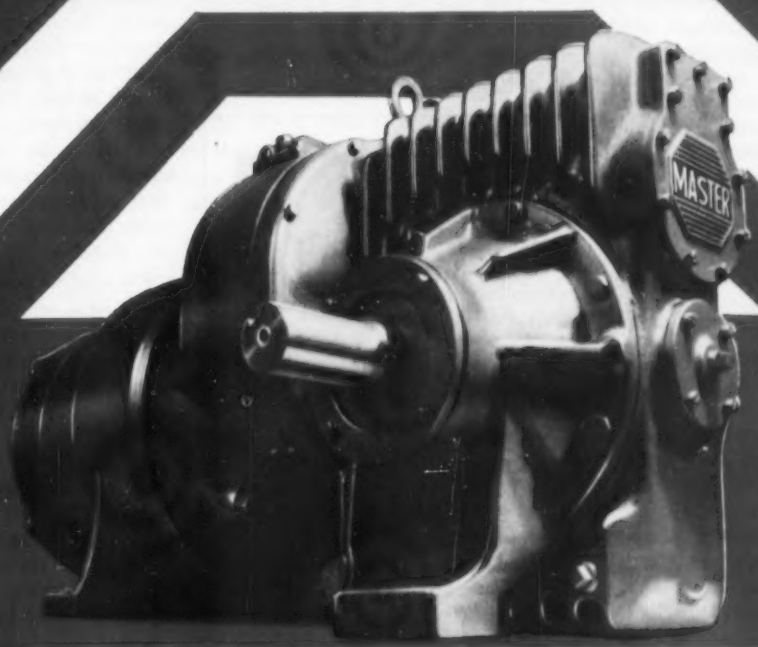

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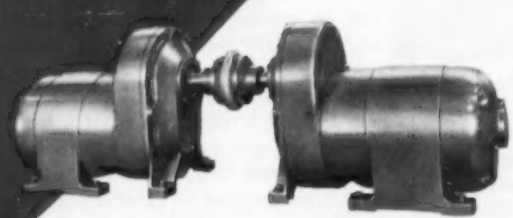

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only under extremely high temperatures and pressures like those existing in the sun. Both of these conditions seemed unattainable on earth until we got the atomic bomb and physicists realized that, for a few millionths of a second, such temperatures and pressures did exist near the center of an atomic bomb.

This realization eventually led to the discovery and development of the thermonuclear type of bomb, in which some of the heavier isotopes of hydrogen, usually with an isotope of lithium, are set off in an atomic bomb to produce the devastating thermonuclear explosions about which you have read so much.

It is the author's opinion, verified by talks with individuals who are much closer to the situation, that the chance of getting controllable power at competitive cost from a reaction which cannot be carried out until extremely high temperatures are reached—measured in many millions of degrees Fahrenheit—or barely possible by bombardment of minute quantities in a very high vacuum with extremely high-velocity sub-atomic particles, is quite remote.

Dr. Smyth of Princeton, formerly atomic energy commissioner, referred recently to the obstacles as being "seemingly insurmountable." Of course, no true scientist will say that anything is impossible, and this tends to give an advantage to those who like to make sensationally optimistic predictions.

Some have said that the generation of controllable power from this source is inherently no more improbable today than was the whole idea of power from atomic fission, say 15 years ago. Actually, however, the possibilities of fusion were known several years before those of fission; and much scientific analysis has been devoted to it over the intervening years.

Most of those who did that early work turned with relief to the possibilities of fission, which has the great advantage of starting at ordinary temperatures and being controllable within any temperature limits set by the materials available.

If a fusion type of process ever were developed, it would almost certainly be extremely complicated and difficult to control; and even though the fuel cost might be lower, the investment would almost certainly be much higher. *Business Week* for August 6, 1955, quoted an unnamed scientist as trying to put matters in general perspective by using these "heavily rounded" and probably exaggerated figures:

- With $10 worth of coal and a $10 stove, you can get $10 worth of heat.
- With $10 worth of uranium, you can get $10,000 worth of heat, but you need a stove that would cost $100,000.
- With $10 worth of heavy water, you could get $100,000 worth of heat, but the stove would cost you $10 million.

Meet the Author

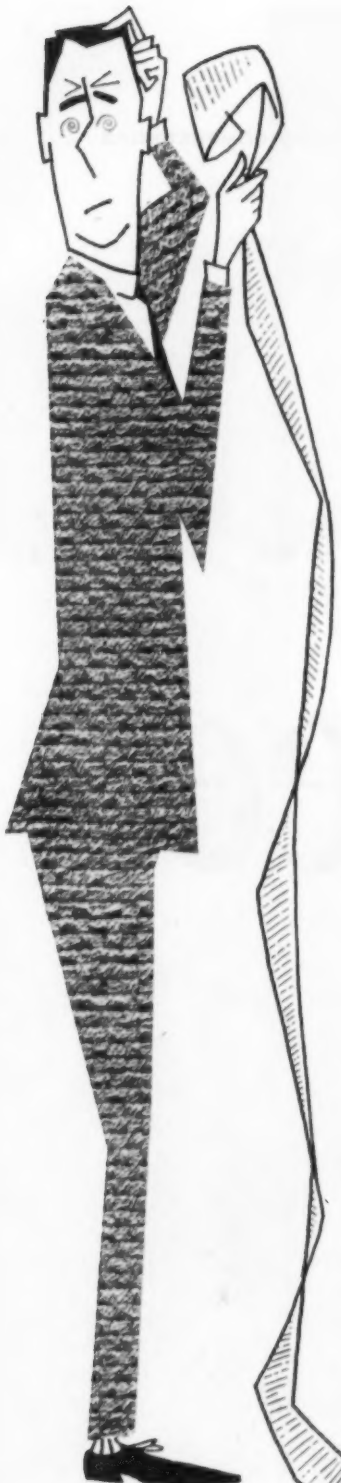
ROBERT E. WILSON is a native of Pennsylvania, a graduate of Wooster College, Ohio, and the Massachusetts Institute of Technology. He began his career as an MIT research associate, then returned there after World War I as director of research and associate professor. In 1922 Dr. Wilson transferred to industry and became assistant director of research at the Whiting refinery of Standard Oil Company (Indiana). Seven years later he was chosen to head the company's development and patent department, then shortly thereafter, he became a director and vice president. From 1935 through 1944 he was head of the Pan American Petroleum and Transport Company, then in 1945 he returned to Chicago to be chairman of the board and chief executive of the parent company, Standard of Indiana. Dr. Wilson has been awarded the Chemical Industry Medal, the Perkin Medal, and the third Lord Cadman Memorial Medal. Just recently, President Eisenhower appointed Dr. Wilson as a member of the General Advisory Committee to the Atomic Energy Commission.

Outlook for Distant Future—Thus far, this discussion has centered primarily on the nuclear fuel outlook for the next 25 years. Beyond that time, any predictions are bound to involve more and more uncertainty, not only because of unforeseen developments in the utilization of atomic energy, but because of uncertainties regarding the rate of discovery of oil in the more distant future. As oil gets harder to find, the long time trend of petroleum costs and prices is upward and likely to continue that way; whereas the trend of atomic power costs is downward and should continue that way for at least the next two decades.

For central power plants in typical U. S. locations, the two curves seem likely to cross sometime between ten and fifteen years from now. In the case of coal, the crossing will probably be later, and vary considerably with freight costs. However, the country's needs for energy are expanding so rapidly (certainly more than doubling in the next 25 years) that the ultimate problem is not what fuel is going to be crowded out, but what can come along to help carry the rapidly growing load.

Petroleum's present advantage in most of its fields of usefulness is so large that only a very major increase in price could prevent it from having all the business it would be able to handle far beyong the next 25 years. It is much more certain that early use will be found for all the petroleum discovered in this country than it is for uranium—weapons requirements will certainly decline, and breeder reactors will sharply reduce prospective uranium requirements for generating a given amount of power.

Barring a world cataclysm, world population in the next century is almost certain to increase by threefold and its power requirements at least tenfold. With this outlook, it seems reasonable to welcome atomic energy with open arms. For the long pull, it will be, not a competitor, but a burden-sharer; and its ultimate availability should still the recurrent cry that we are running out of oil and that the government should therefore take us over. # #



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2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
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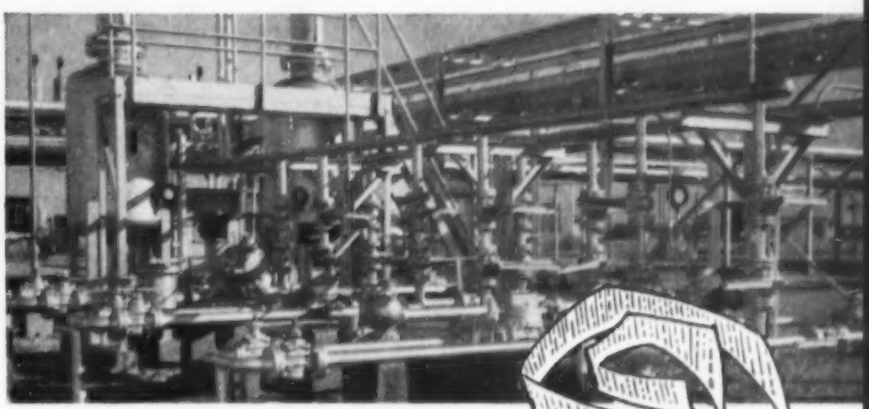

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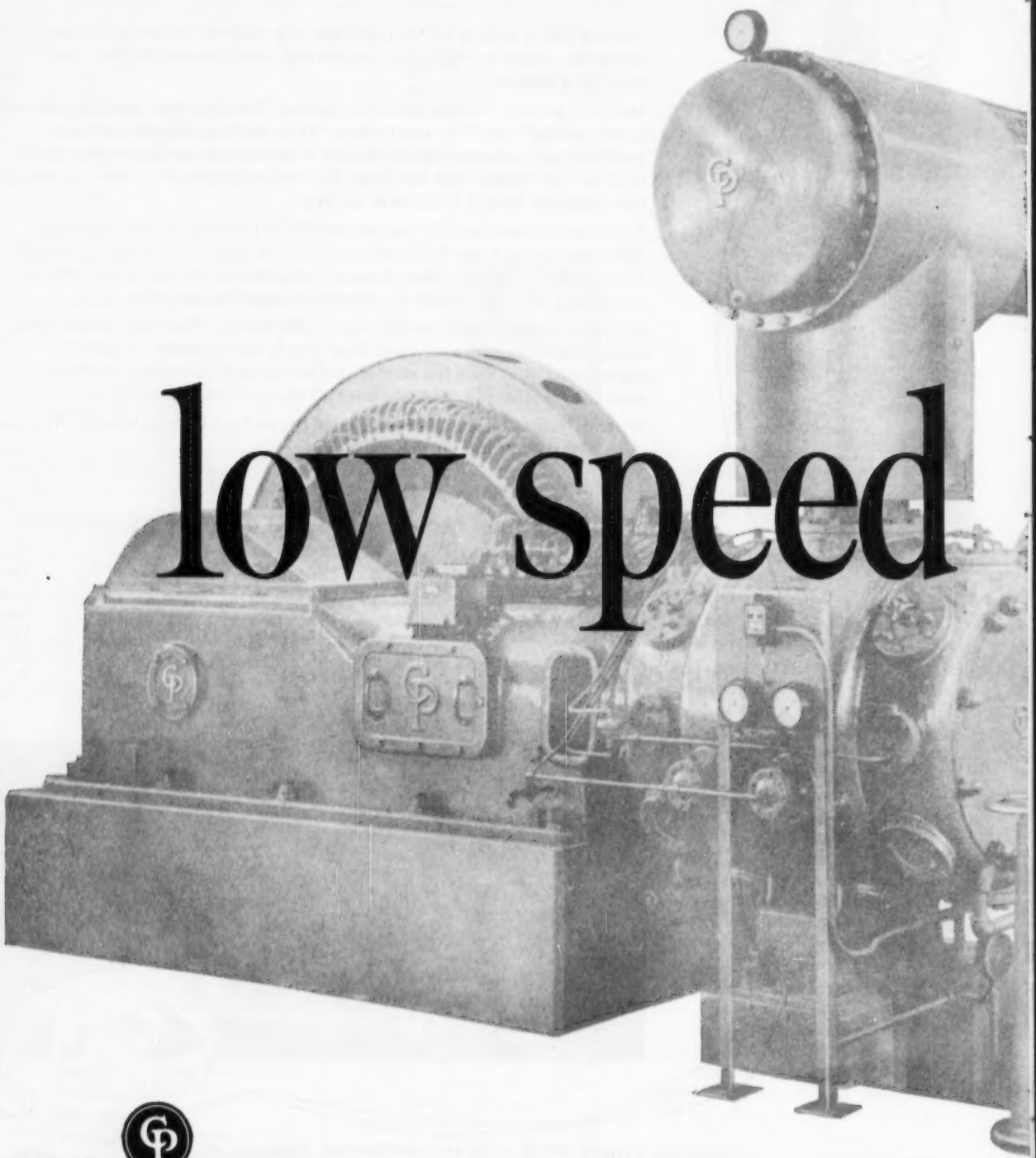

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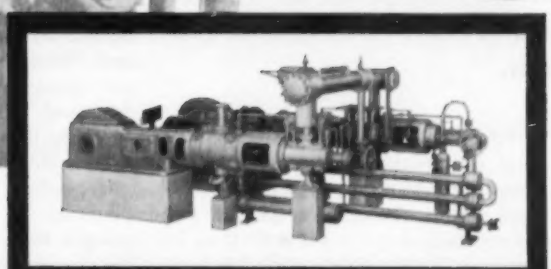

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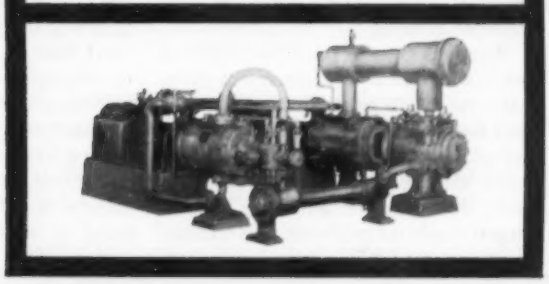

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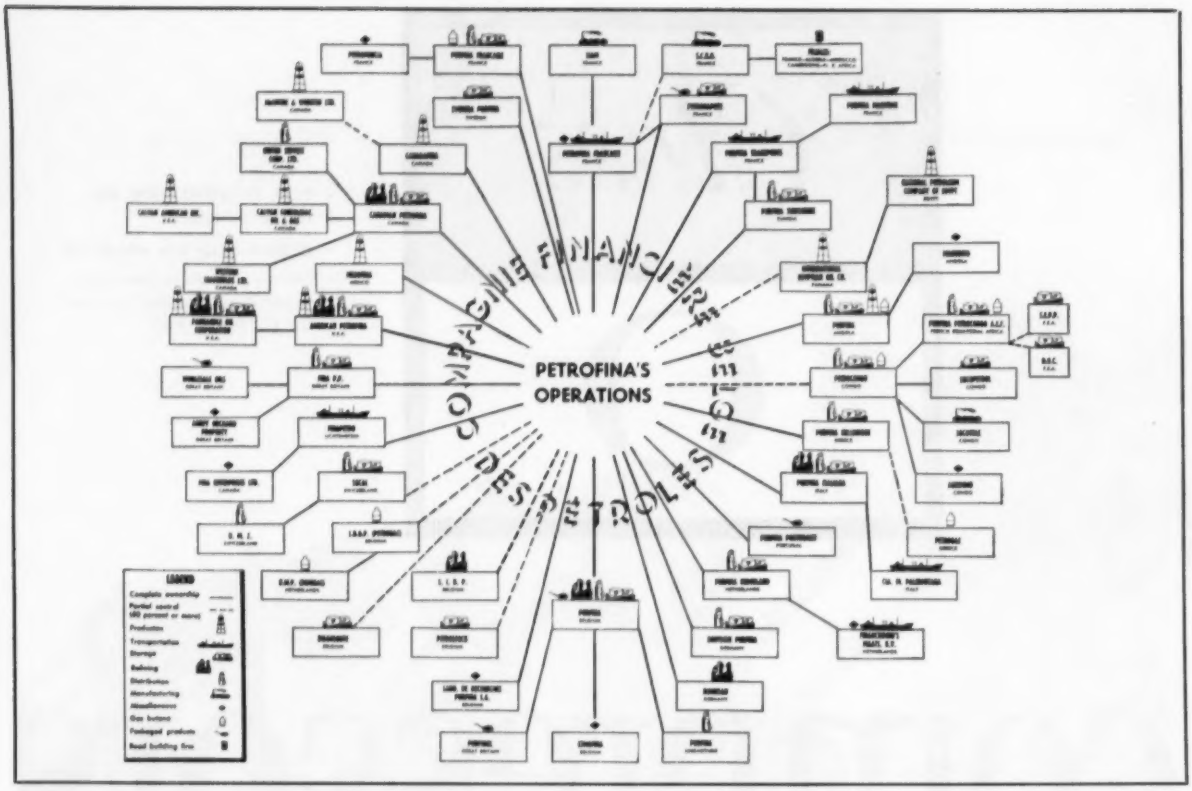

Postwar Construction:

Petrofina Expands Refining On Three Continents

World War II caused widespread destruction to the Belgian firm's facilities and resulted in drastic geographic relocation of operations.

COMPAGNIE FINANCIERE Belge des Petroles (Petrofina) has since the close of World War II rapidly expanded its refining capacity through new construction, plus purchase and modernization of existing facilities.

The war so drastically affected Petrofina's activities there is hardly any valid comparison between the prewar and postwar setups. The firm's plants were almost completely destroyed during hostilities, and immediately thereafter the Iron Curtain dropped across the face of Eastern Europe to cut off its entire source of crude, and also much of its refining and distribution facilities. Petrofina, despite great progress in oil exploration during the postwar period, still experiences a crude oil deficit, as its increase in refining capacity has been even more rapid.

Petrofina was formed in 1920 to purchase from Swiss interests a company operating properties in Rumania that had belonged to German interests before World War I. During the interim between the two global conflicts, Petrofina became the second largest crude oil producer in Rumania (with up to 17,500 barrels daily), had the largest pipe line system there, and its Concordia Refinery at Ploesti had a capacity of 50,000 barrels daily. Marketing companies were organized in many European and African countries, another refinery near Dunkirk in France was on stream running 10,000 barrels per day, and a fleet of tankers was acquired.

Victim of War—World War II almost totally demolished Petrofina's plants. Rumanian holdings were lost, together with marketing facilities now behind the Iron Curtain in Bulgaria and Hungary. The French refinery and many European terminals were destroyed. All but one tanker of the Petrofina fleet was sunk.

It is difficult to visualize a more catastrophic blow than that dealt Petrofina by World War II. The group's recovery and growth during the ten years since V-J day is particularly remarkable in view of the almost total chaos in which it found its plants at the close of hostilities.

Today, the Petrofina group consists of more than 60 separate firms, operating in a score of countries on four continents. It is active in refining in Europe and North America, and will build a refinery in Angola, West Africa. The group represents, pri-

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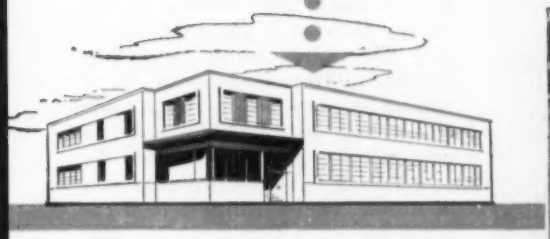

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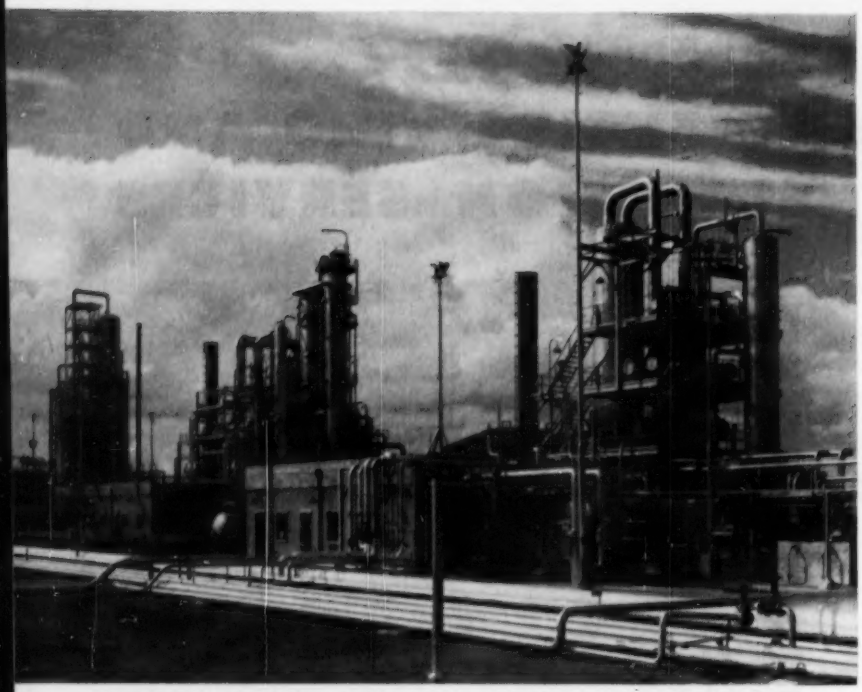
Petrofina Expands Refining . . .



The modern Petrofina refinery located at Antwerp, Belgium, is currently running near its 60,000 barrels-per-day plant capacity. Ownership is shared on a 50-50 basis with British Petroleum Company, Ltd.

marily, a refining and marketing concern, with refineries located in Italy, Belgium, Germany, Canada, and the U. S. Petrofina markets in many free European countries, in Africa, Canada, and the U. S. Its tanker fleet includes 18 ships owned and 30 on long-term charter, aggregating 1,018,093 deadweight tons.

Petrofina now has a modern refinery at Antwerp, Belgium, with ownership shared on a 50-50 basis with British Petroleum Company Ltd. This 60,000 barrels-per-day plant went on stream in 1951, and is currently running almost at capacity. The ultra-modern Canadian Petrofina plant at Montreal commenced operations late in 1955 and is now running 18,000 barrels per day, just under its 20,000-barrel capacity. Three small refineries in Italy acquired after the war at Genoa, Milan, and Rome have an aggregate capacity of 22,000 barrels per day and are currently running 13,000 barrels. The refinery at Wichita Falls, Texas, recently acquired when Petrofina merged American Petrofina Inc. and Panhandle Oil Corporation, is running 6,600 barrels per day through a 7,000 barrel-capacity plant. A West German refinery at Mulheim, with a daily capacity of 7600 barrels, has recently been acquired with the acquisition by Petrofina of 75 percent of the stock of Ruhrbau GmbH.

Thus the gross refining capacity of Petrofina companies is now about 115,000 barrels daily, and totals about 80,000 barrels per day net after deducting capacity represented by other interests in the same plants, such as BP's half interest in the Antwerp refinery. Crude production now nets over 20,000 barrels per day, about half of which is from western Canada. Significant reserves developed there, and also in Angola and on the Sinai peninsula of Egypt by Petrofina affiliates promise a large increase in production as soon as the relatively recent discoveries can be more fully developed. It may, however, be a number of years before group crude output matches refinery capacity, as new refineries definitely planned for construction and scheduled expansion of existing plants will raise total capacity above 150,000 barrels per day.

Makes Petrochemicals. Petrofina is also active in the manufacture of petrochemicals in Western Europe. A Belgian affiliate, Societe Chimique des Derives du Petrole S. A. (Petrochim), is engaged in the manufacture of basic petroleum products from gas, piped from the Antwerp refineries. In addition, Laboratoires de Recherches Purfina, S.A., another Belgian affiliate and a research company engaged in a variety of projects for the Petrofina group, is active in petrochemical research.

Thus, in about ten years since the close of World War II, Petrofina has surpassed its prewar producing and

This Canadian Petrofina refinery at Pointe-aux-Trembles in Quebec, Canada, began operations in September, 1955. The plant's total cost was about $30 million.

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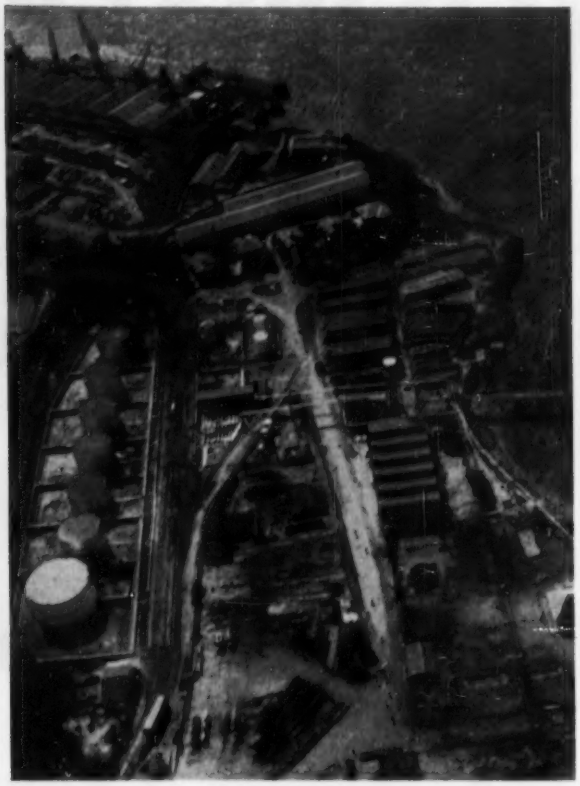
Petrofina Expands Refining . . .



The petroleum installations of the Purfina Congo are located at the port of Leopoldville on the Congo River between the Belgian Congo and French Equatorial Africa.

refining capacity, all of which was destroyed and/or confiscated. The company's reconstruction emphasizes several postwar trends. Refineries in Western Europe and at Montreal are in net consumer, rather than net producer areas. Long tanker hauls for crude, in larger tankers, are the rule. And small, multi-unit refineries, with emphasis on higher quality and specialized products rather than on greater quantity, are a trend reflected by Petrofina's construction. Too, the group's manifest interest in petrochemicals largely represents another postwar trend.

New construction plans include a 20,000-barrel-daily refinery at Duisburg near the Ruhr-Rhine confluence west of Essen in Germany, and a refinery to process locally-produced crude at Luanda in Angola, Southwest Africa. The Luanda refinery will have a capacity probably in the order of 25,000 barrels per day, but more definite plans are being delayed pending the evaluation of the oil discovery made in 1955 in the nearby coastal area. Production is from a fractured limestone at 8400 feet and the structure is believed to afford significant reserves of light crude. The discovery, when made, was over 2600 miles from the nearest oil production in Algeria, and is in a unique position marketwise, particularly now that the refinery will definitely be built. It is nearer than any other crude source to the South Africa consumer area, barren of crude oil supplies and with prospects dim for finding any. If the Suez Canal were closed, Angolan production would be in effect brought nearer to European markets. And by water, Angola is essentially as close to the Argentina-Uruguay-Southern Brazil consumer region as Western Venezuela is. Thus Petrofina was quick to organize producing and refining organizations for Angola.

Units in Operation. A breakdown of the units in operation in Petrofina refineries, and those under construction, follows:

Belgium: Antwerp; two topping units, one vacuum unit, thermal reformer, fluid catalytic cracker, catalytic polymerization unit, treating and sweetening units. A 10,000 barrels-per-day platformer and a 10,000 barrels-daily gas oil hydrofiner are being built and scheduled to go on stream early in 1958.

Germany: Mulheim; topping unit and sweetening facilities.
Planned for Duisburg; topping unit, catalytic reformer, and gasoil hydrofiner.

Italy: Genoa; topping and sweetening facilities, platformer, thermofor catalytic cracker.
Milan; topping facilities, lube oil and asphalt plants.
Rome; topping and sweetening facilities, thermofor catalytic cracker, perco reformer, and asphalt plant.

Canada: Montreal; topping and sweetening facilities, vacuum unit, ultraformer, gasoil hydrofiner, Houdryflow catalytic cracker, catalytic polymerization unit, alkylation unit, and fluid coker.

United States: Wichita Falls; topping and sweetening facilities, thermal cracking unit, fluid catalytic cracker, and catalytic polymerization unit. Platformer under construction.

Petrofina's refineries provide high-octane requirements as the market demands. Even the older and smaller refineries in Italy have been newly equipped to provide 98 to 100 octane gasoline to satisfy the requirements of that country.

It is likely that the Antwerp refinery will be almost doubled in capacity during the next decade or sooner. In collaboration with AGIP, the present Rome refinery may be replaced with a new 30,000 barrels-per-day refinery.

The ultra-modern Canadian Petrofina refinery at Pointe-aux-Trembles, Quebec, Canada, near Montreal, has a number of interesting features. The new plant went on stream in September, 1955. The 3800 barrels-daily fluid coker, completed later, went on stream this year. Total cost of the entire plant was about $30 million. The 16,000 barrels-per-day catalytic cracker is 285 feet high. It runs 10,000 barrels of fresh feed daily and

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Experience and perfection go into the making of KOVEN Individualized Equipment . . . 75 years of careful devotion to detail, of time and research spent in making each piece increasingly better and more efficient at the lowest possible costs.

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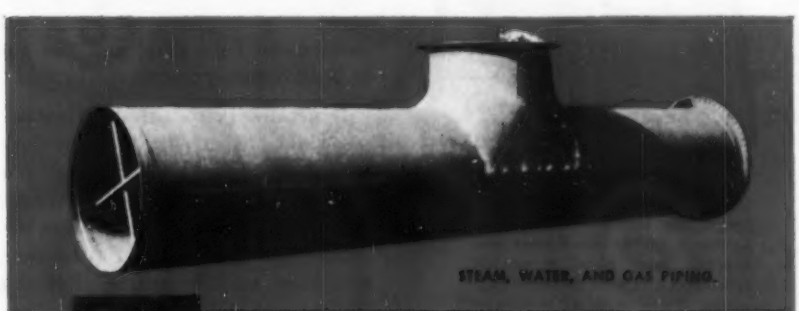
For individualized equipment built to your exact specifications, contact KOVEN today. Call or write for a consultation with a trained representative, and send for Bulletin #550. There's no obligation.

BULK STORAGE TANK MADE OF STEEL

X-RAY INSPECTION FOR QUALITY CONTROL

***KOVEN** equipment in all metals and alloys includes:* **High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; light and heavy fabricated piping and plate exhaust ducts. Shop and field erected storage tanks to 2 million gallons. High vacuum testing on liquid oxygen storage tanks.**



STEAM, WATER, AND GAS PIPING

SPECIALISTS IN INTRICATE FABRICATION USING:

- STAINLESS STEEL
- ALUMINUM
- MONEL
- NICKEL
- INCONEL
- ALL CLAD MATERIALS

FABRICATION TO ALL A.S.M.E. CODES

Koven *FOR INDIVIDUALIZED EQUIPMENT SINCE 1881*

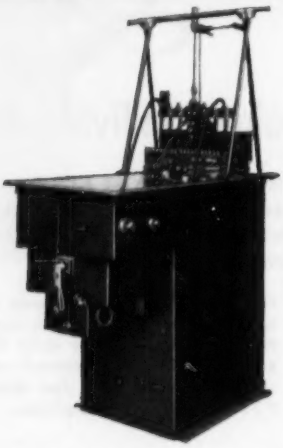
L. O. KOVEN & BRO., INC., 154-P OGDEN AVE., JERSEY CITY, N. J.
PLANTS: JERSEY CITY, N. J. • DOVER, N. J. • TRENTON, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

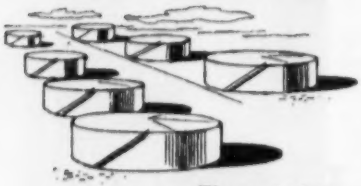
BUILT TO THE REQUIREMENTS OF OIL MEN

EC&M

TOTALLY OIL IMMERSED 50,000 KVA interrupting capacity MOTOR STARTERS have many advantages



Contactor and Relay Panel are bolted together for raising as a unit above the oil. No leads or bolts to disconnect. Shown is Cat. No. 2645A Lifting Mechanism, available at small cost.

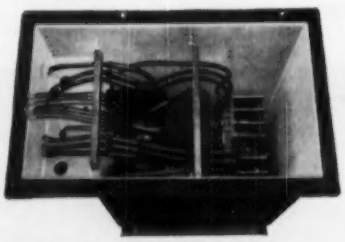


These starters are designed specifically for Division 2, semi-hazardous locations. They are low in first cost and are easy to service when inspection or maintenance are necessary. They require little floor space.

High interrupting capacity is inherent . . . 50,000 KVA and no power fuses required. The well-known Type ZHS Magnetic Contactor has been certified for this rating. It is of heavy-duty construction to assure trouble-free operation.

Before buying 2300-5000 volt motor starters, investigate EC&M Type ZHS Starters. They provide economy in installation, operation and maintenance, and are available in a range of horsepower sizes.

Write for Bulletin 1062-20.



Looking down into starter showing anti-syphon lead construction from contactor, control transformer and overload relay panel to conduit connection box with threaded couplings. Starter with oil disconnect switch shown in views above.

6884

SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

about 6600 barrels of recycle stream, heavier than diesel fuel. The refinery produces kerosene and jet fuels, regular and premium gasolines, stove, diesel, and heavy fuel oils, and propane. There is storage capacity for approximately 1 million barrels of crude and 1 million barrels of products.

The gasoline yield is 58 percent on Middle-East crude (Kuwait). With completion of the fluid coker, the refinery has nine gasoline streams. Economic production of 100 octane fuel has been achieved. Kuwait crude is being run, part of a long-term contract with British Petroleum Company Ltd. dated from the start of the post-war period, when Petrofina had no crude oil supply of its own.

All nine process units are operated from one central control room in the highly automatic refinery. Pneumatic and electronic instruments coupled with an elaborate color code facilitates rapid identification of instruments on the control panel. Light colors denote light products, heavy colors for heavy products. Red and green lights in lines denote flow and no flow conditions, and a flashing light indicates an abnormal situation. Logging of temperature, pressure, flow, etc., is achieved automatically.

Since the piping is painted in accordance with the color code, the refinery has a very colorful outer appearance. Coke flows in pipe painted black, crude and heavy feed stocks in maroon pipe, gas oils in dark green, stove and diesel oils through dark blue; while gasolines are in light red, petroleum gas in light yellow, water in pale green, chemicals and catalysts in light gray, and flue gas in light brown.

Generally, Petrofina group companies can be expected to increase their producing, refining, marketing, and all other phases of their business rapidly in the future, as they have in the recent past. All the refineries are running close to full capacity. Refining and petrochemical plants, particularly those in Western Europe, are excellently placed in the area of most rapidly increasing consumption.

(All data on Petrofina operations in Middle-East submitted before present crisis developed in that area.)

Unique? Yes!

Because it's a Rheem steel pail. It was made by the world's largest producer of steel containers—RHEEM. That's a lot of experience working for you. As for protection for your product, the linings in Rheem steel pails are bonded directly to the steel and oven baked to prevent flaking and peeling. Rheem pails are available in 1-gallon to 15-gallon sizes; plain, colored or lithographed; lined or unlined; double head or crimp lug type covers. Why not call Rheem today and find out more about sending your products to market—first class—in Rheem steel pails.

YOU CAN RELY ON Rheem MANUFACTURING COMPANY

Leading Producer of Steel Shipping Containers

LINDEN, N. J., SPARROWS POINT, MD., RICHMOND AND SOUTH GATE, CALIF., HOUSTON, CHICAGO, NEW YORK, NEW ORLEANS

RHEEM MANUFACTURING COMPANY
5001 Jefferson Hwy., P.O. Box 4027, Carrollton Station, New Orleans 18, La.
1025 Lockwood Drive, Houston 20, Texas

Please send me detailed information on Rheem Steel Pails.

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COMPANY_____

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CITY_____ STATE_____

PR-11

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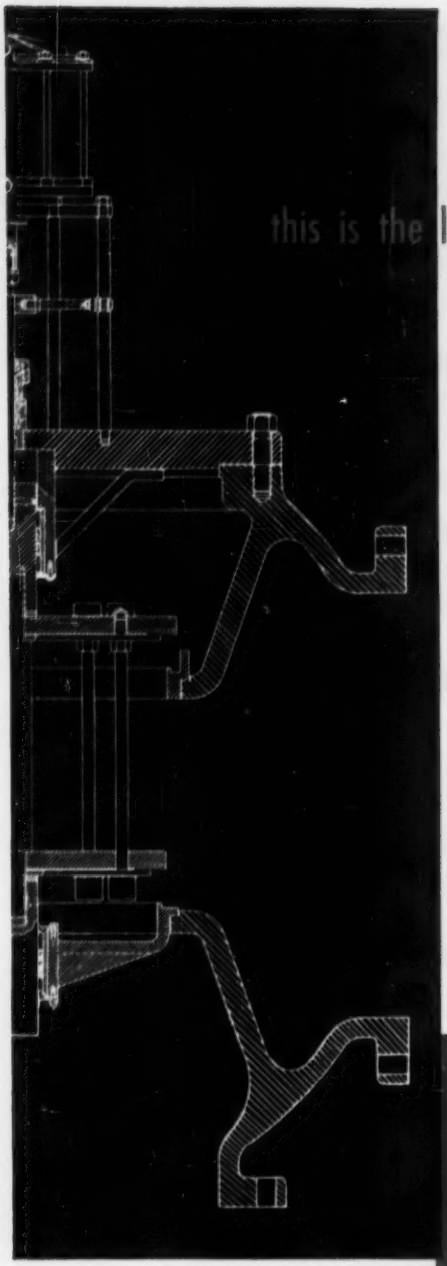


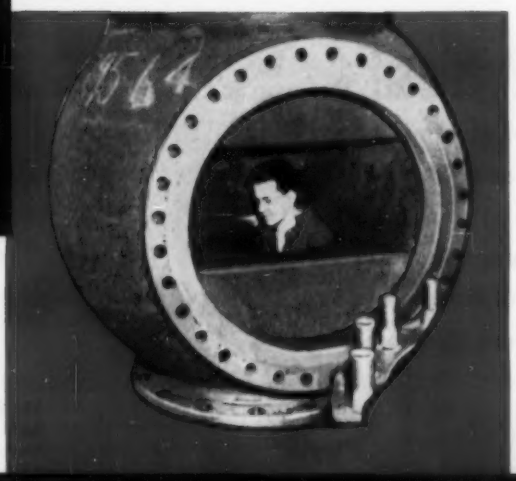
this is the largest double-seated control valve ever made

When you are talking *big* control valves, talk to Kieley & Mueller. K&M is the largest manufacturer of the big ones, control valves above 16 inches. Standard globe-type valves are available in 20, 24, 30 and 36 inch sizes; even larger valves will be produced on special order.

This 36-inch double-seated angle valve closes snugly on giant Teflon seats. The inner valve positions responsively, gliding on special roller-slide bearings. It's massive, but is operates protected by a K&M patented torque resistor. Beyond the problem of size, this valve is mounted on its side, and it has been performing creditably for over four years.

BIG or small, if it's control valves, you'll like the pitch-in, helpful approach of your local K&M representative . . . plus capable engineering and manufacturing follow-thru at the K&M plant.

Write for Bulletin CV-53.



ABOVE: Partial cross-section of K&M 36-inch valve showing general construction.

AT RIGHT: Actual size of a 36 inch valve can be visualized from this illustration of a workman inside the valve body performing finishing operations.

K&M

KIELEY & MUELLER, INC.

64 Genung Street • Middletown, New York

78th Anniversary . . . Oldest U.S. Pressure and Level Control Valve Manufacturer

What's Happening . . .

. . . in the Industry

A Job for Computers—Pipe Stresses

Little Delay When Computers Handle Complex Systems

The wizardry of electronics has come to the aid of mechanical engineers who are called upon to solve the complex problems of high temperature process piping and power plant piping systems. Now, electronic "brains" are being used to compute the expansion of metals with rising temperatures under increasingly high temperature and pressure conditions of use.

Pipe expands more than nine inches in a hundred feet when the temperature is elevated to 1000 F. or higher and pressures are 2000 pounds per square inch. These are now common operating conditions. Such expansion would put destructive forces and stresses on the pipe and associated equipment if the piping system were not designed to be flexible so that there will be no concentration of stress at any point.

Proper provisions for safe distribution of thermal stresses in piping have taken skilled stress analysts as long as a month or more to complete complex design computations in order to satisfy all code requirements. These computations are almost completely independent of heat expansion problems in the design of equipment which the piping serves, i.e., the boilers, turbines, heat exchangers, process equipment, etc.

Now, Blaw-Knox Company's Power Piping Division, Pittsburgh, has a new method of making design computations that eliminates delays by taking advantage of the high accuracy and speed of electronic computers. With this automatic method it is possible to complete computations within a single working day.

The automation of these engineering problems was accomplished recently in an 18-month joint research project of the Power Piping Division with Arthur D. Little, Inc. This fact makes it evident that the availability of electronic computers for solving complex mathematical problems often does not offer immediate means of solving problems of this type advantageously. In this instance, since the existing "classical approach" was not well adapted to these machines, basic principles of stress calculations were re-examined in order to obtain results quickly and accurately by electronic computation.

The new method used by Blaw-Knox is important not only for its great time saving in completion of plant design but also as a contribution in the conservation of engineering manpower. It is an advancement in the art of using an electronic computer for practical problems of this type as well as a fundamental contribution in mathematics and pure mechanics.

When the computer is operating the operator (left) is alert to signals on the control console indicating erratic operation, which may be induced by peculiarities of the problem or by other factors. Blaw-Knox Company's representative (right) and a representative of Arthur D. Little, Inc., (center), make intermediate checks on parts of the problem as figures are tabulated on the automatic typewriter, a member of the Univac System. Magnetic tapes, used in controlling the computer, for collecting coded results, and for storing intermediate data, are shown on machines at the right.

The data that are fed into the machine consist only of dimensions that can be taken easily from an isometric drawing of the piping system, and a few physical properties of the pipe material. These data are first tabulated on simple forms from which the figures can be fed readily onto a magnetic tape. The actual machine part of the computation takes less than an hour. The total time required includes that for putting the data on tape, checking the accuracy of a printed transcription, putting the tape through the computer, and for a machine transcription of the computed results that are obtained on output tape, into orderly tabular figures.

The high accuracy of computations is indicated by the fact that all results are carried to six significant figures. Inconsistencies in the input data are detected by the machine which will inform the operator of the error and, if permitted, will subsitute the correct dimension automatically. Accuracy is limited only by the accuracy of the input data. No short-cut approximations are made because all complicating factors and special variables can be taken fully into account.

Unions Seek "Substantial" Wage Hikes

Moves for new wage hikes in the oil industry are being made by oil unions, and refiners will be the first to feel their impact. President A. O. Knight of the Oil, Chemical, and Atomic Workers International Union, has set the stage for a strong and early campaign for substantial wage increases.

Higher living costs, higher oil industry profits, and higher employe productivity are behind the union demands. Knight contends that the increased profits realized in the petroleum industry since the close of World War II should be more equitably distributed between capital and labor.

Other unions seeking wage increases are: Central States Petroleum Union, Inc., Chicago, representing 23 locals and about 12,000 employes of Indiana Standard, bargaining for a 9 percent pay hike, equivalent to 23.8¢ an hour; five Jersey Standard groups that make up the International Petroleum and Chemical Workers asking for 25 percent increase, with a 25¢ an hour minimum; Humble's Baytown Employes Federation trying again for the new contract they have been seeking for some time.

Knight has called the union's bargaining committee to a meeting in Denver, December 7, to act on his recommendations

MODEL "M" SERIES

Marksman tubeless electronic potentiometer strip chart RECORDER for recording and controlling such variables as temperature, speed, strain, pH and many others.

- No vacuum tubes. Sensitivity of 5 micro-volts or less.
- Potentiometer for thermocouple (TCB protected) or radiation pickup, Wheatstone bridge for resistance pickup.
- Full selection of standard scale ranges . . . 11" calibrated chart width.
- Selector knob changes chart speed . . . 5 speeds per unit without gear change.
- Single or multi-record units available.
- Equipped for 115 or 230 volts — no transformers needed.
- Additional features: Automatic standardization . . . cold junction compensation for thermocouple use . . . battery condition indicator for potentiometer . . . built-in chart saver . . . designed for standard 19" relay rack.

WEST *Instrument* **CORPORATION**
SALES OFFICES IN PRINCIPAL CITIES
4357B W. MONTROSE, CHICAGO 41, ILL.
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NOW you can have all these practical advantages in a single instrument. Write for Bulletin M.

the trend is to **WEST**

What's Happening . . .

for a general wage increase in the immediate future. "We are going to ask for something substantial," says Knight, "not just a token increase."

Cosden Adds Polybutenes

For three years Cosden Petroleum Corporation experimented with a semi-commercial unit for the production of polybutenes. Now that company's chemical division has swung into full scale commercial production of polybutenes, with a million-gallon capacity plant at Big Spring, Texas.

In the Cosden process, isobutene is polymerized over an aluminum trichloride. Resulting reactions take place at temperatures as low as —30 to —40 F., depending on the desired viscosity of the product.

Polyvis, which is the trade name for Cosden's polybutene, is used in making caulking and sealing compounds, pressure sensitive adhesives, and vibration dampners.

Indiana Standard Acts On Subsidiary Consolidation

Standard Oil Company (Indiana) is proposing that three of its chemical subsidiaries be consolidated into one, under the name of Amoco Chemicals. This is part of the functional organization of nine subsidiaries into four.

In the meantime, Standard has gone ahead with one name change. Hidalgo Chemicals will be known as Amoco Chemicals Corporation. Later, Indoil Chemical and Pan American Chemicals will be consolidated into Amoco Chemicals. Following the consolidation, the chemicals subsidiary will have its headquarters in Chicago with H. Forrester as president.

Big Horn Refining Leases Ohio Oil Refinery at Lovell

Big Horn Refining Company, newly organized by Wyoming, Montana, and eastern businessmen, has leased The Ohio Oil Company's Lovell refinery, and has started manufacturing asphalt from Hamilton Dome crude.

Elbert O. Sowerwine, Jr., Cody, Wyo., Big Horn president, said that his company will ultimately buy the refinery which Ohio Oil closed nearly a year ago, but for tax reasons is temporarily leasing it.

D-X Sunray Cuts Crude Runs

D-X Sunray Oil Corporation has reduced crude runs 10 percent at its Tulsa and Duncan refineries. These latest cuts come on the heels of similar cutbacks throughout the industry. (PETROLEUM REFINER, October, p 95.)

Current Sunray reductions amount to about 7000 barrels a day at Duncan. Runs at the Tulsa plant were cut 5000 barrels a day in September. The two plants normally run about 115,000 barrels a day of crude.

Education for Automation

During Automation Week in New York, November 26 to 30, 1956, several thousand executives, engineers and technical men will upgrade their knowledge of the

For more data on advertised products, use Readers' Service Cards, last page.

Here's the pitch on dependable WELDING FITTINGS

Welding fittings from J&L Supply are guaranteed accurate within ASA tolerances. Cut your pipe with confidence!

- Store stocks for your pick-up requirements.
- More comprehensive stocks centrally located and promptly available.
- On special specifications, direct factory shipment from the most versatile plants in America — welding fittings engineered to enable you to improve piping designs and reduce costs.

The line includes fittings of easy-to-weld JALTEN, made by J&L. Ideal for use with high-tensile, high-yield pipe.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

7-GA

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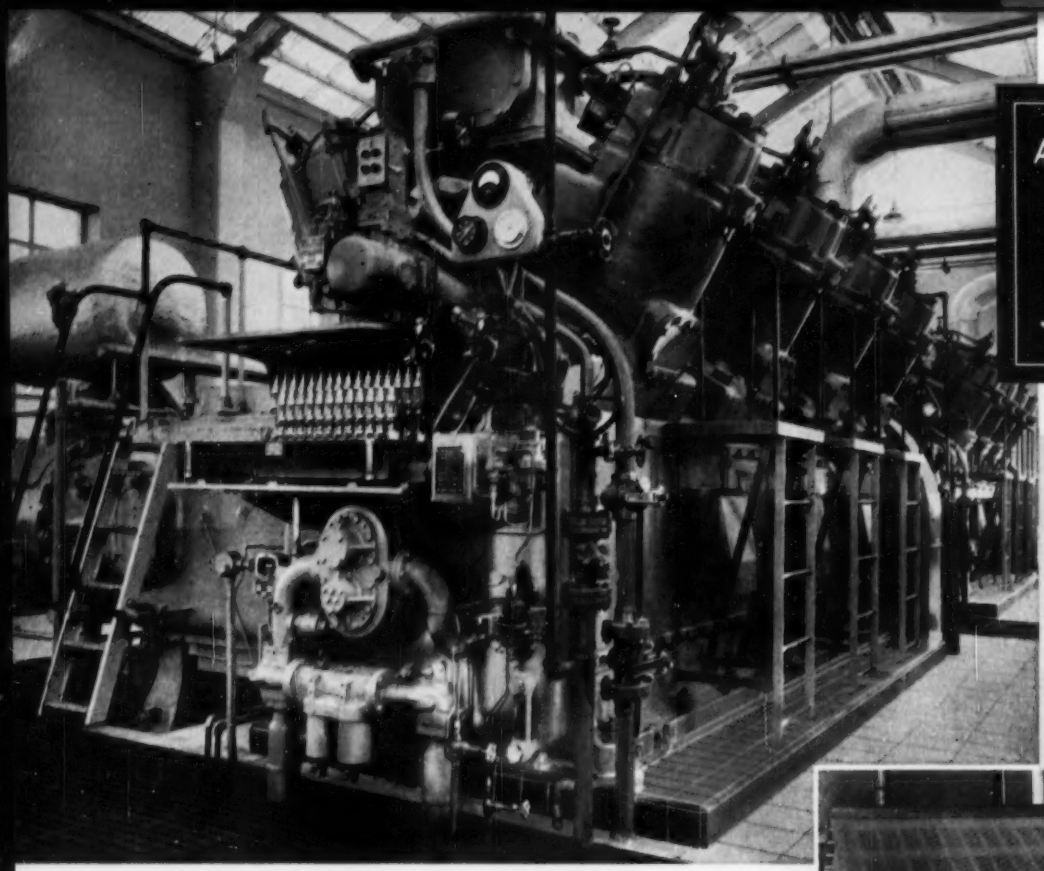
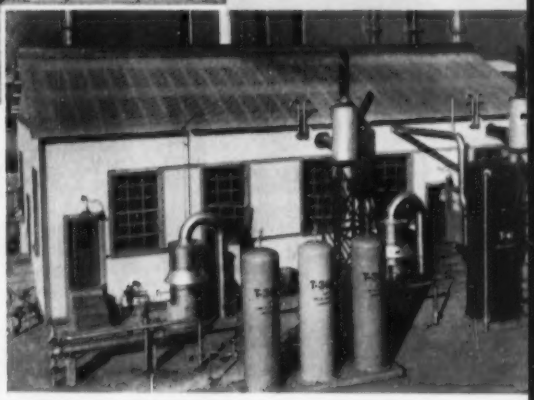


Another example of efficient compression at lower cost

Petroleos Mexicanos' Reynosa station, showing 8-cylinder Cooper-Bessemer V-angle compressors.

Exterior view of the neat, compact Reynosa gasoline plant.



COOPER-BESSEMER COMPRESSORS

FOR PETROLEOS MEXICANOS

. . . extreme dependability
. . . extremely economical

● The compression of natural gas and propane in Petroleos Mexicanos' gasoline plant, Reynosa, Tamps., Mexico, is a perfect example of extremes . . . all good!

Handling three pressure ranges, and handling them reliably and at low cost, is a brief summation of the Cooper-Bessemer performance story in this modern station.

Two 8-cylinder Cooper-Bessemer compressors handle plant process gas as well as compressing gas for distribution in northeast areas of Mexico and for export.

Known not only for performance . . . the name Cooper-Bessemer means cooperation and service all along the line. Detailed installation recommendations, experienced service engineers, availability and rapid delivery of spare parts from centrally located warehouses . . . each helps make your job easier, helps keep costs at a minimum. Find out for yourself, next time plans call for compressors up to 6,000 hp, check with Cooper-Bessemer.

ENGINES: GAS • DIESEL • GAS-DIESEL

COMPRESSORS: RECIPROCATING AND CENTRIFUGAL, ENGINE OR MOTOR DRIVEN

cooper-bessemer

MOUNT VERNON, OHIO • GROVE CITY, PENNA.

Branches in principal U.S. Cities, also: Edmonton and Calgary, Alberta • Halifax, N.S. • Caracas, Venezuela • Mexico City, Mex.

fundamentals of automation as it applies to their own fields. For four mornings that week the Third International Automation Exposition will become a giant school. Several thousand such men will receive a basic and practical education on automation equipments for offices, laboratories, processing plants, and manufacturing.

High Hopes for "Silent Sam" In API Anti-Smog Campaign

Seven private agencies, working on aspects of air pollution for the American Petroleum Institute, have brought their projects together in an allied effort to speed the answers to some questions about Los Angeles smog. Latest arrival was "Silent Sam," the pollutant-detecting instrument conceived and built by the Franklin Institute at Philadelphia for research by the American Petroleum Institute.

"Silent Sam," 17 feet tall when standing, and weighing 1300 pounds, was brought to Los Angeles in a mobile laboratory trailer to analyze smog with his ultra-long-path infrared absorption cell and spectrometer.

At the suggestion of the independent Air Pollution Foundation, "Sam" is starting his local smog investigation at the Stanford Research Institute laboratory. Here, the Foundation is conducting one of its key research projects on the role of automobile exhaust in eye irritation, plus studies of atmospheric aerosols and gases responsible for various manifestations of smog.

"Silent Sam" can detect and identify smog impurities as unerringly as fingerprints can pinpoint a lawbreaker. He is expected to expose hitherto undetectable pollutants which exist in minute sizes and amounts in the atmosphere.

"Sam" is actually the second of his kind. An earlier version has been in use in Franklin Institute's Philadelphia laboratories for two years. Both instruments were built as part of a long range research program financed by the American Petroleum Institute.

At an API meeting in Montreal last May, Franklin researchers announced that their studies of synthetically polluted air with the older instrument had uncovered the existence of "Compound X"—a chemical which might be the key to new understanding about smog formation. It is hoped that "Sam" will determine the role, if any, that Compound X plays in actual Los Angeles smog.

"Sam" consumes air in 22-cubic foot gulps. His stomach is a 200-inch diameter, 10-foot long stainless steel tube, into which atmospheric samples are pumped. Infrared radiations bounce back and forth through these samples, and an analyzer separates them into coolers and measures the strength of each.

The work is being done by Dr. Edgar Stephens and Philip Hanst of Franklin, under supervision of Dr. William H. Claussen, executive secretary of the API Smoke and Fumes Committee.

Union Carbide Buys Visking

Union Carbide and Carbon Corporation has entered the cellulose and polyethylene field by purchasing The Visking Corporation. The basis for the agreement is one share of Union Carbide stock for 2½ shares of Visking. Visking stockholders will vote on the proposal sometime probably within the next 60 days.

Badger Forms Affiliate

Badger Manufacturing Company of Cambridge, Massachusetts, and Comprimo N. V. of Amsterdam, Holland, have formed a jointly-owned subsidiary company, Badger-Comprimo N. V., with headquarters at Mauritskade 39, The Hague, Holland. This new firm will furnish engineering, procurement and construction services to the petroleum refining and chemical industries desiring to utilize European equipment and currencies.

This new firm will enable foreign affiliates of the American organizations to obtain Badger services on other than a dollar basis and to take advantage of the European equipment manufacturing facilities.

What's Happening. . .

N. Y. Slated as Site of 1959 World Petroleum Congress

The Fifth World Petroleum Congress will be held at the Coliseum in New York City May 30 through June 6, 1959. C. Eugene Davis, of 10 Claychester, Kirkwood, Missouri, reecently retired vice president of Shell Oil Company and now a consultant, is general secretary of the Congress. Thirty nations are expected to be represented by more than 5,000 oil scientists and other visitors.

Eger V. Murphree, president of Esso

A SUPERIOR SWEETENING REAGENT IN PETROLEUM REFINING

CUPRIC CHLORIDE DI-HYDRATE

TC

CUPRIC CHLORIDE

MADE FROM VIRGIN COPPER FROM OUR OWN MINES

PRODUCED BY THE

TENNESSEE CORPORATION

MINERS OF COPPER, ZINC, IRON AND SULPHUR

We are in a position to supply your needs on annual, semi-annual or monthly contract basis—also smaller quantities in drop shipment lots.

TYPICAL ANALYSIS

Copper	37.00% minimum
Moisture	12.00% maximum
Fe	.04% maximum
Zn	.01% maximum
Copper Oxychloride—less than	.50% maximum

For samples make request on your company letterhead.

TENNESSEE TC CORPORATION

617-639 Grant Building, Atlanta, Ga.

CHECK THESE FEATURES

High Copper Content
Lower Moisture
Uniform Particle Size
Uniformity
Availability

For
1. Quality Improvement
2. Cost Reduction

Other Tennessee Corporation products:
Ferric Sulfate (Ferri-Floc), Copper Sulfate and Sulfur Dioxide.

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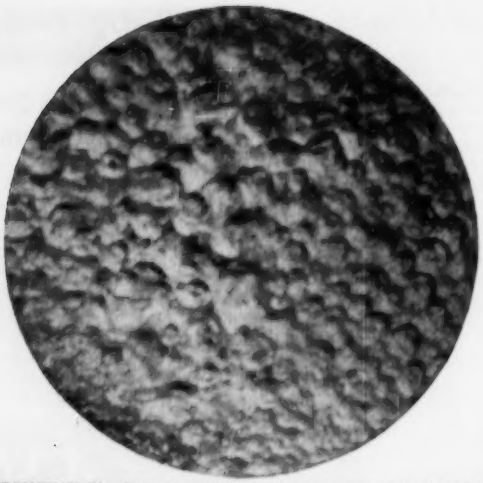
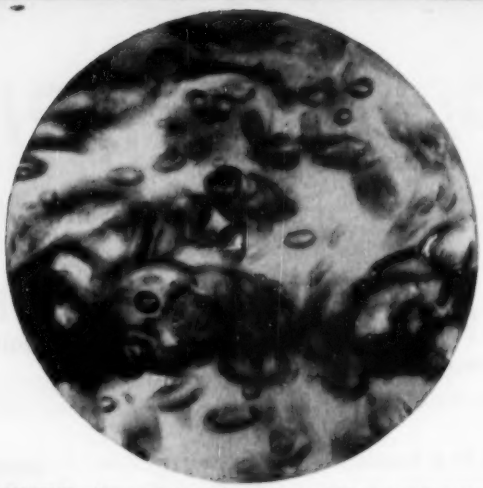


BEFORE CONCENTROL—Foaming of highly alkaline solution in glass test cylinder.

HERE'S PROOF:

CONCENTROL

CONTROLS FOAM AND BOILER WATER CARRY-OVER



AFTER CONCENTROL—Same solution after addition of 12 ppm of Concentrol Antifoam.

Where boiler water carry-over is caused by foaming due to high alkalinity and high proportion of dissolved solids in the water, Concentrol provides a low cost, effective method of chemical treatment and control. Supplied in liquid, powder or briquet form—to be fed continuously or in slugs to boilers—Concentrol is essentially a surface agent that causes breakdown of bubble film to prevent foam formation. Formulations of Concentrol can include organic sludge conditioning agents and other water treatment chemicals for boiler treatment as well as antifoam. Fast acting and resistant to hydrolysis or breakdown under normal boiler temperatures and pressures. Eliminates need for costly pre-treatment of water and high blow-down rate.

Write for NAME OF BIRD-ARCHER WATER TREATMENT ENGINEER NEAREST YOU.

BA 607

BIRD-ARCHER

WATER TREATING ENGINEERS

THE BIRD-ARCHER COMPANY, 4337 N. AMERICAN ST., PHILADELPHIA 40, PA.

New York, Chicago

The Bird-Archer Co. of California, 883 Mission St., San Francisco

Offices also in Canada and Mexico

What's Happening . . .

Research and Engineering Company, currently on one-year leave of absence while serving as special assistant to the Secretary of Defense heading the U. S. guided missiles program, is chairman of the Congress' top governing group. Murphree was re-elected to this post during the Fourth World Petroleum Congress at Rome in 1955.

It is expected that about 200 technical papers analyzing technical advances affecting the world oil industry will be presented.

Amoco Refinery Employes Receive Safety Certificate

For the second straight year, employes at American Oil Company's Savannah refinery have earned a National Safety Council Award Certificate for working a year without a disabling injury. Employes worked a total of 298,478 man hours in 1955 without a single lost-time accident.

Technical Program Planned For MCA Cleveland Show

Two symposia arranged by the Manufacturing Chemists Association, special sessions on new chemicals and equipment for the industry, arranged by the Cleveland Section of the American Chemical Society, and the Industrial and Engineering Chemistry lecture series will highlight the technical program at the 9th National Chemical Exposition in Cleveland, November 27-30, 1956.

The Manufacturing Chemists Association symposium of November 28, will deal with chemical processing equipment standardization.

"Plant and Laboratory Safety" will be the topic of the other Manufacturing Chemists Association symposium which will be held November 29.

Dow Chemical Acquires Bay Refining, Pipe Line

Dow Chemical Company has exercised its option to buy Bay Refining Corporation and Bay Pipe Line Corporation, both with headquarters at Saginaw, Mich.

Dow will build a petrochemical plant on the site of land adjacent to the Bay Refining facilities at Bay City, Mich. The plant will draw petroleum products from the refinery for use in producing ethylene.

Dow would not disclose the price paid for the two companies nor the proposed cost of the new plant which is slated for completion in January, 1958.

Tiny Silsbee Platformer Upgrades Natural Gasoline

At Silsbee, Texas, a small Platformer has been started up to process natural gasoline from a nearby cycling plant. One of the smallest in operation, the Platformer has a design capacity of 700 B/SD. It is processing East Texas debutanized natural gasoline boiling in the range of 110 F to 400 F. The charging stock is obtained direct from a gas cycling plant (producing natural gasoline and distillate) adjacent to the unit. The finished Platformate, of about 98 leaded octane, is being marketed as a premium gasoline blending component.

The unit is operating under license of Universal Oil Products Company to the South Hampton Company, organized re-

For more data on advertised products, use Readers' Service Cards, last page.

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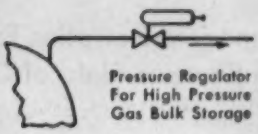
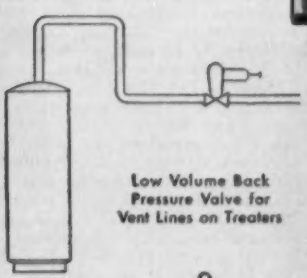
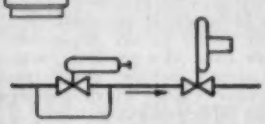
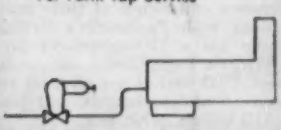
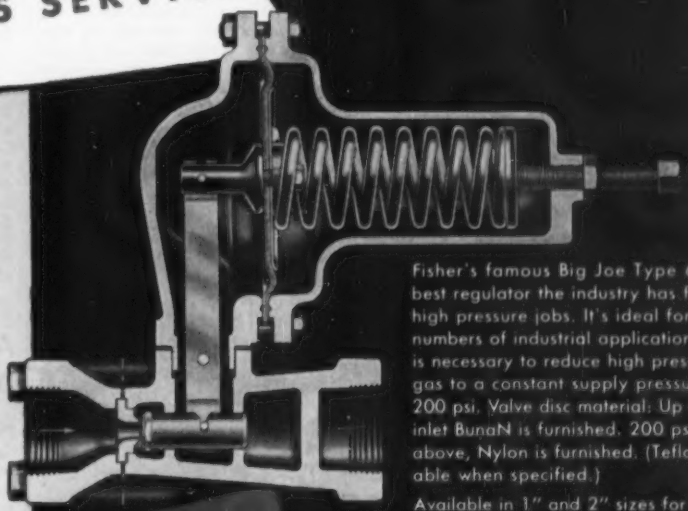






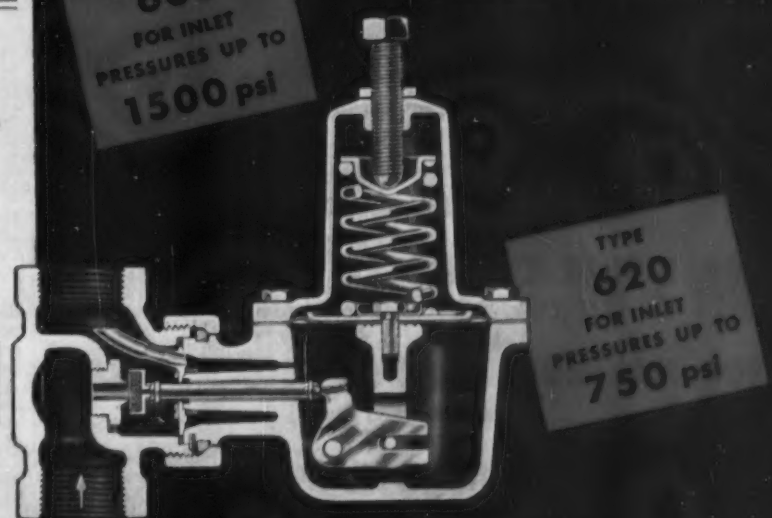




TYPE 630 FOR INLET PRESSURES UP TO 1500 psi

Fisher's famous Big Joe Type 630 is the best regulator the industry has for rugged high pressure jobs. It's ideal for countless numbers of industrial applications where it is necessary to reduce high pressure air or gas to a constant supply pressure of 5 to 200 psi. Valve disc material: Up to 200 psi inlet BunaN is furnished. 200 psi inlet and above, Nylon is furnished. (Teflon is available when specified.)

Available in 1" and 2" sizes for inlet pressures up to 1500 psi and outlet pressures 5 psi to 200 psi.



TYPE 620 FOR INLET PRESSURES UP TO 750 psi

For real economy the Fisher Type 620 pounds to pounds regulator is used on same applications as 630 "Big Joe" where pressure and flow requirements do not exceed 750 psi and reduced pressure not above 100 psi.

For inlet pressures up to 750 psi with malleable iron or cast steel body; up to 150 psi with cast iron body. Outlet pressure ranges: Type 620—3 to 60 lbs. (4 springs). Type 621—3 to 100 lbs. (5 springs). Valve disc material: BunaN when inlet pressure is 300 psi or less, and Nylon when inlet pressure exceeds 300 psi.

Sizes: ¾", 1" and 1¼" with cast iron or cast steel body. ¾" and 1" with malleable iron body.

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LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

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cently by John C. Breaker, Houston.

Speculation has arisen since the unit went on stream that such an operation could be the forerunner of a growing trend toward producing from condensate greater quantities of high octane natural gasoline which are now desired by refiners. It is believed that erection of small Platforming units adjacent to the natural gasoline plants—possibly portable installations which could be moved with ease to other locations should this become desirable in the future—would materially help to satisfy the growing demand for catalytically reformed gasolines.

The practicality of such an approach to the problem of producing larger quantities of catalytically reformed motor fuels from these well condensates is seen in the operation of the South Hampton Platformer itself. It was designed essentially for unattended operation, although one of two operators is always nearby in the event of an emergency.

There are no feed storage tanks for the Platforming operation. Charge stock is piped direct from the cycling plant. The excess gas produced in the Platformer is returned to the cycling plant for the recovery of propane and heavier components. Fuel for the Platformer is supplied by the cycling plant. A portable gas engine supplies power for the compressor and charge pump, while electricity is used to drive miscellaneous other pumps.

The unit is producing a 97.7 leaded octane Platformate of approximately 9.5 Reid Vapor Pressure, with yields of 88 to 89 volume percent.

Large Increase Forecast For West German Refining

West Germany refining capacity is expected to nearly double during the next five years, according to the German Mineral Oil Association. Refining capacity by 1961 may reach about 200 million barrels per year. Fuel oil consumption reached about 15 million barrels last year and is increasing so rapidly that it may reach 90 million barrels by 1960.

The Ruhr is expected to replace Hamburg as West Germany's refining center, considering the refineries planned or under construction by Esso and by Shell at Cologne, and another Cologne-area plant being planned by British Petroleum. The capacity of the Hamburg refinery area, however, is expected to triple in five years due to expansion of existing facilities. Widespread conversion of industry from coal to oil, even in the case of some steel plants, is the main reason for the increase in fuel oil demand.

American Petrofina Expands Announces Slate of Officers

American Petrofina, Inc., has acquired Panhandle Oil Corporation by purchasing 600,000 shares of Panhandle stock. American Petrofina, Inc., incorporated in Delaware and headquartered in New York, announced the following officers:

Harry A. Jackson, president, a veteran of 35 years oil experience, mostly with Tidewater Oil Company. His work has been largely in the transportation and foreign fields. Before leaving Tidewater he was a vice president, and general manager of eastern operations. **Roger Gilbert,** financial vice president, having been president of Panhandle, and with the company since 1951. Gilbert spent 20 years with the investment firm, Atlas Corporation, of which he was a vice president. During World War II he served as a Lieutenant Colonel in the Army finance department. **W. D. Heath Eves,** vice president, whose former affiliations include Anglo-Iranian Oil Company (now British Petroleum) and Foster Wheeler Corporation.

American Petrofina, Inc., will combine the capital resources, marketing and transportation experience of their previous operations with Panhandle's facilities. Panhandle has a 7500-barrel-per-day refinery in Wichita Falls, Texas, oil production of about 3500 barrels per day, oil reserves of about 15 million barrels, and gas reserves of 110 billion cubic feet.

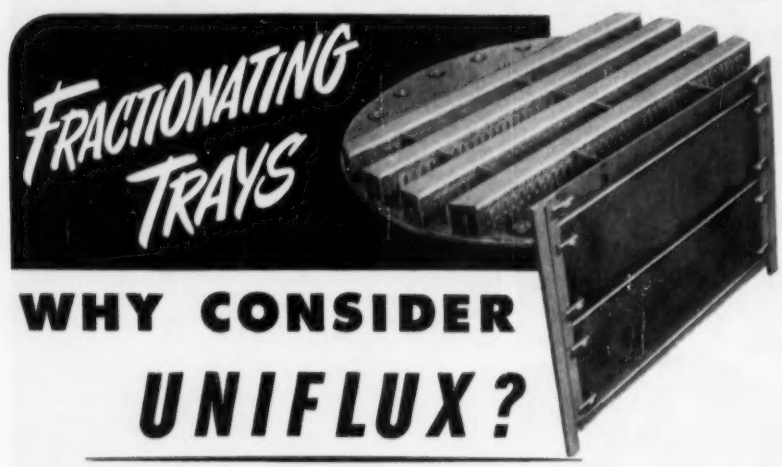
In addition, Panhandle has 250 marketing outlets in Texas, Oklahoma, and New Mexico.

RCI Adds Petrochemicals

Entry into the field of basic petrochemicals by Reichhold Chemicals, Inc., through long term contracts with Escambia Chemical Corporation, has been announced.

Arrangements for the multi-million dollar program making RCI a major producer of basic petrochemicals were negotiated by Theodore S. Hodgins and John W. Stevens, RCI vice presidents, with Escambia Chemical Corporation.

Escambia Chemical Corporation is jointly owned by Electric Bond and Share, United Gas Corporation and National



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(Equal or Better Than Conventional Designs)

FOR HIGHER EFFICIENCY? . . . . . YES!
(Closer Approach to Equilibrium)

FOR MAXIMUM FLEXIBILITY? . . . . YES!
(Wide Operating Range)

FOR MINIMUM MAINTENANCE? . . . YES!
(Simplified Installation, Self-Cleaning Characteristics)

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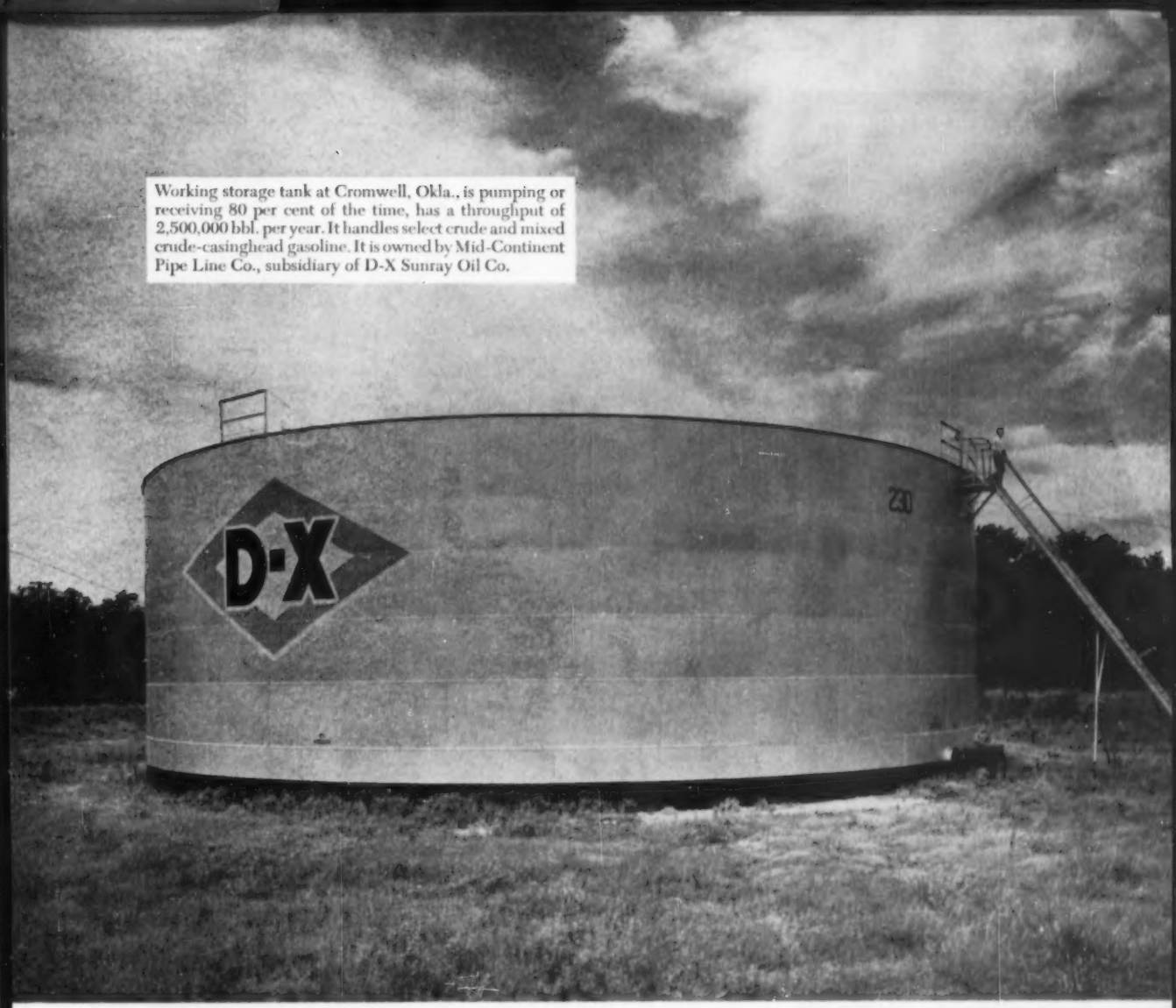

Working storage tank at Cromwell, Okla., is pumping or receiving 80 per cent of the time, has a throughput of 2,500,000 bbl. per year. It handles select crude and mixed crude-casinghead gasoline. It is owned by Mid-Continent Pipe Line Co., subsidiary of D-X Sunray Oil Co.

Still cutting evaporation loss after two years

with Microballoon spheres*

Two years ago, D-X Sunray Oil Co. equipped this 35,000-bbl. cone-roofed tank with "Microballoon" spheres made from BAKELITE Brand Phenolic Resins. Since that time, this vapor-stopping blanket has reduced evaporation loss an estimated 70 to 80 per cent according to D-X Sunray.

Installing the spheres took eight men about three hours. Within 24 hours, the "Microballoon" spheres had formed a blanket spread over the entire oil surface. Today, this foam seal is still effective after some 5,000,000 bbl. of oil have been pumped through the tank.

These results indicate the economy and effectiveness of this method of evaporation control. To learn more about it, write today to Department VL-132.

*Registered trade-mark of The Standard Oil Co. (Ohio)

for evaporation control . . .

BAKELITE BRAND RESINS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

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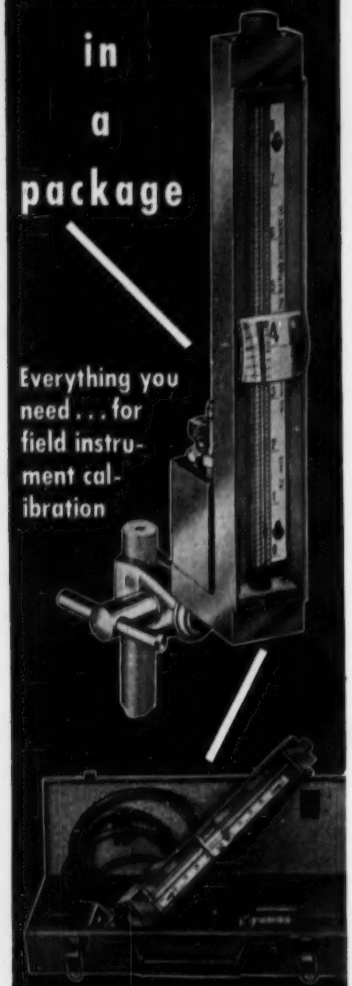

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What's Happening . . .

Research Corporation. Escambia presently is producing ammonia, nitric acid, and ammonium nitrate near Pensacola, Florida, and polyvinyl chloride resin will be on stream early in 1957.

The new facility for the production of methanol will be located near Pensacola, Florida.

API Awards Certificates

Certificates of appreciation, awarded by the American Petroleum Institute for outstanding services in several fields of the oil industry, were to have been awarded at the Chicago meeting as follows:

Oil Industry Information Committee: Roy B. Glass, Socony Mobil Oil Co., Kansas City, Mo.; D. R. McCallum, Sinclair Refining Co., Denver; Robert A. Douglass, Ethyl Corp., Tulsa; Arthur J. De Blois, De Blois Oil Co., Pawtuckett, R. I.; Conger Reynolds, retired Standard Oil Co. (Indiana), Chicago.

Division of Finance and Accounting: Phillips C. Salmon, Socony Mobil Oil Co., New York.

Fundamental Research: G. M. Knebel, Standard Oil Company (New Jersey), New York; Robert E. Wilson, Standard Oil Company (Indiana), Chicago; Wheeler G. Lovell, Ethyl Corp., Detroit.

American Petroleum Industries Committee: David C. Proctor, Gulf Oil Corp., Pittsburgh.

Safety and Fire Protection: C. D. Norris, The Texas Co., New York.

Octane Ratings Climb

Gasoline in October showed national weighted averages of 97.1 octane for premium and 90.2 for regular, according to latest monthly survey of antiknock quality compiled by Ethyl Corporation.

The averages for both grades were 0.1 octane higher than in September. Compared with a year ago, the premium average was 1.1 octane higher and the regular average was 1.4 higher.

Erratum

Last month in PETROLEUM REFINER on page 253, under the heading "Refining Outlays Hiked," the figures quoted as "capital expenditures for oil refining" should have been labeled as "petroleum and coal industry survey estimates." A corrected version of this article follows.

According to a joint survey of Commerce Department and Securities and Exchange Commission, capital expenditures for petroleum and coal industry will climb to about $3.341 billion in 1956. This is against $2.798 billion in 1955, and $2.684 billion in 1954.

Houston Company Buys Western State Refinery

Northwest Production Company of Houston is buying Salt Lake City's Western States Refining Company. Acquisition of the refining ties in with plans for a multimillion-dollar pipe line being built by Northwest affiliates from the four-corners of Colorado, New Mexico, Arizona, and Utah to Salt Lake City.

Sale of the firm will be accomplished on a par-for-par exchange of stock.

MEETINGS CALENDAR

NOV.	
12–15	American Petroleum Institute, Annual Meeting, Conrad Hilton Hotel and Palmer House, Chicago.
13–14	Chemical Market Research Association, Harvard Business School, Cambridge, Mass.
15–16	National Association of Corrosion Engineers, North Central Regional Meeting, Detroit.
20	Manufacturing Chemists' Association, Midwinter Conference, Statler Hotel, New York.
23–30	American Society of Mechanical Engineers, Statler Hotel, New York.
26–30	Third International Automation Exposition, Trade Show Building, New York.
26–30	National Exposition of Power and Mechanical Engineering, Sponsored by the American Society of Mechanical Engineers, Coliseum, New York.
27–30	American Chemical Society, National Chemical Exposition, Cleveland, Ohio.
30	Natural Gasoline Association of America, Panhandle Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
DEC.	
3– 5	Air Pollution Control Association, Semi-Annual Meeting, Rice Hotel, Houston.
5– 6	The Asphalt Institute, Annual Meeting. Site still unselected.
6– 7	American Petroleum Institute Oil Industry Information Committee, Biltmore Hotel, New York.
6– 8	South Wide Chemical Conference, Sections of the American Chemical Society, Memphis.
9–12	American Institute of Chemical Engineers, Annual Meeting, Statler Hotel, Boston.
JAN.	
21–25	American Institute of Electrical Engineers, Winter General Meeting, New York.
28–30	Eighth Plant Maintenance and Engineering Conference, Statler Hotel, Cleveland.
FEB.	
4– 8	American Society for Testing Materials Committee Week, Benjamin Franklin Hotel, Cleveland.
22	Natural Gasoline Association of America, Permian Basin Regional, Scharbauer Hotel, Midland, Texas.
MAR.	
3– 6	American Institute of Chemical Engineers, Greenbriar Hotel, White Sulphur Springs, Virginia.
25–27	Western Petroleum Refiners Association Annual Meeting, San Antonio.
27–29	American Power Conference, Annual Meeting, Sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago.

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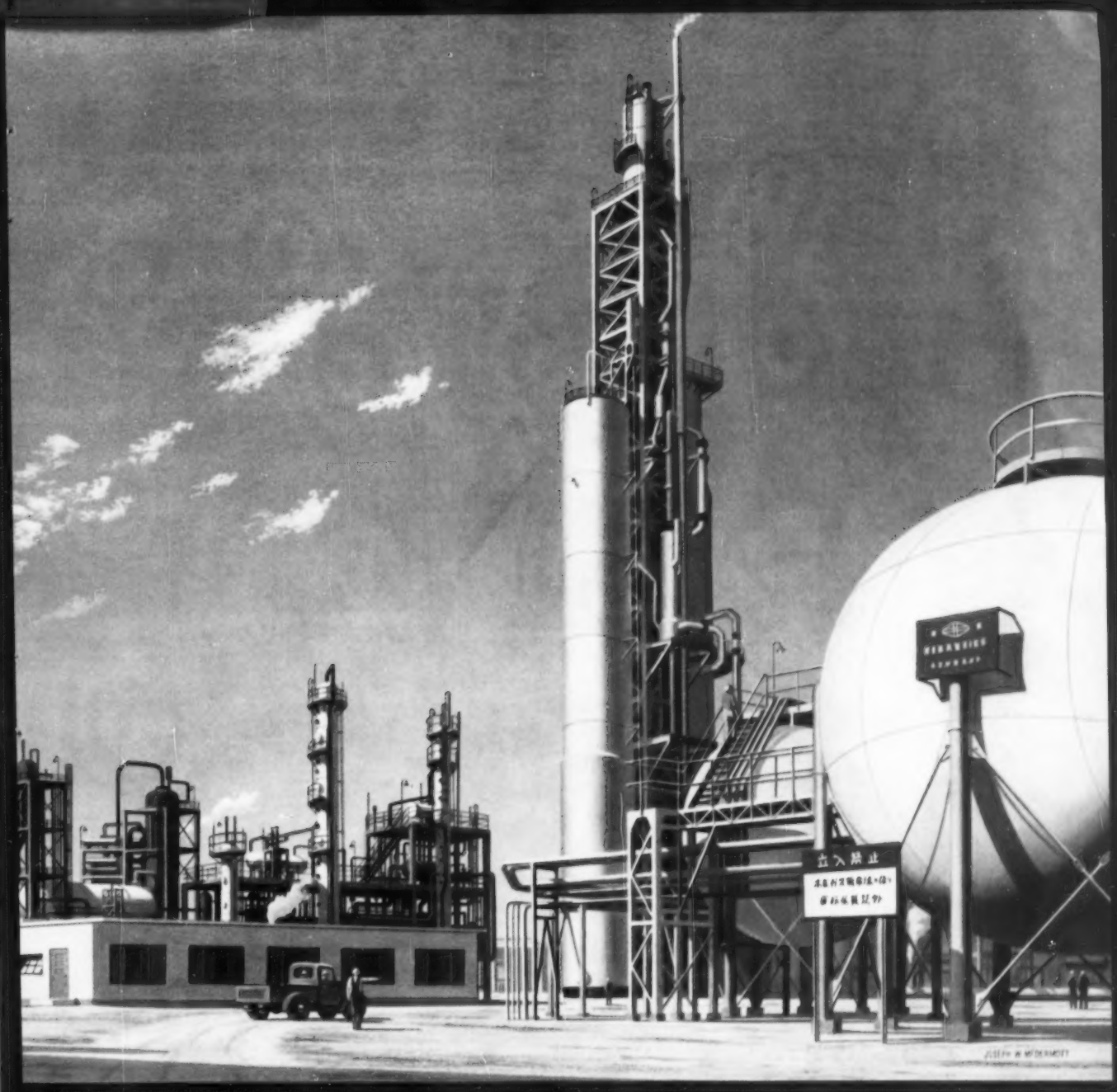

DAIKYO OIL COMPANY, LTD., JAPAN

The Houdriflow Catalytic Cracking Unit operating at the Yokkaichi, Japan, refinery of the Daikyo Oil Company, Ltd., is the first to be built in the Orient. On stream since June, 1955, this cracker processes 4,200 barrels a day of gas oil to produce high octane gasoline.

The Houdriflow process utilizes the inherent advantages of the moving bed system to provide maximum yields of high-octane gasoline and distillate fuels. This, in turn, minimizes degradation to low value products, such as fuel gas and coke. World-wide commercial experience has demonstrated the flexibility, simplicity of operation and low maintenance features of this process. For further information, write to: Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pa.

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This worm had to turn, evenly...

needed, some way to cool off hot-tempered worms!

AFTER the worms were heated and quenched, their threads were not uniform. Distortion had already destroyed the precision machining so vital for efficient operation and long life.

Technicians traced the trouble back to the tempering process. The soft steel had hardened unevenly and warped. The result: crooked worms with uneven tempers.

This is what Texaco did about it . . .

Available quenching fluids were not doing the job. A superior one was indicated. So – Texaco went to work on a tough problem – came up with the answer – a fluid that equalized metal tempering as never before.

Now the hot steel could be quenched uniformly. Result: true and smooth-turning worms with even tempers!

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What's Happening . . .

. . . *Among Men* in the Industry

Lewis

Schoch

Dr. Warren Kendall Lewis, Massachusetts Institute of Technology professor, was the first lecturer in the **E. P. Schoch** Lecture Series at the University of Texas. Dr. Lewis, recognized by the American Chemical Society as outstanding chemical engineer of 1956, praised Dr. Schoch as one of the founders of chemical engineering and father of the chemical and petroleum industries in the South. The lecture series was established by ex-students of Dr. Schoch, who taught at the University of Texas 60 years before retiring in 1954. This lecture series was initiated on October 16, Dr. Schoch's 85th birthday.

J. W. Lane, Socony Mobil Oil Company, Inc., was named 1957 president of National Lubricating Grease Institute at that organization's 24th annual meeting in Chicago in October.

Lane, who has spent practically his entire career in the petroleum industry, is manager of the automotive division of Socony Mobil's lubricating department in New York City. He has been active in NLGI for some time, most recently serving as vice president as well as chairman of the program committee for the 1956 meeting.

Dr. William A. Pardee Gulf Research and Development Company, Pittsburgh, Pa., has been awarded the Scroll of Honor of the American Chemical Society's Division of Industrial and Engineering Chemistry.

Dr. Pardee, a chemical engineer in Gulf's petrochemical section, process division, was honored for his outstanding services which have contributed to the growth, success and prestige of the Society and the division.

The award-winner has been a member of the ACS for 20 years, during which time he has taken an active part in Society operations. He is secretary of the Society's committee on nominations and elections, and is a member of the advisory board of the monthly *Industrial and Engineering Chemistry*, an ACS publication. He is a former chairman of the ACS committee on national meetings and divisional activities, and a former member of the advisory board of the weekly *Chemical and Engineering News*, official organ of the Society.

Dr. Pardee graduated from Emory University in 1936. He received the Doctor of Engineering degree from Yale University in 1941 and joined Gulf Research Development Company that year. In addition to the ACS, he is a member of the American Institute of Chemical Engineers.

Richard E. Lauterbach, manager of manufacturing for the General Petroleum Company has been elected president of the Engineers Club of Los Angeles. Past president **Maurice L. Dickinson,** chief hydraulic engineer for the Bechtel Corporation, was unanimously elected to the chairmanship of the Board of Directors.

Dr. Carroll A. Hochwalt, vice president for research, development and engineering of Monsanto Chemical Company, has been named winner of the 1956 Midwest Award of the American Chemical Society's St. Louis Section.

Hochwalt

Dr. Hochwalt is widely known as an administrator of industrial research, as well as for his earlier work on ethyl gasoline, detergents, synthetic rubber, synthetic fibers and polymers for use as plastics. He was cited by the award committee "for scientific achievement, for leadership in industrial research, and for contributions to the scientists as a citizen."

Dr. Hochwalt is the twelfth recipient of the Midwest Award, conferred annually on a midwestern scientist who is judged to have made "meritorious contributions to the advancement of pure or applied chemistry or chemical education." Presentation of the award, and inscribed gold medallion, will be made at a banquet November 5.

J. Frank Drake, former president and retired chairman of the board of Gulf Oil Corp., Pittsburgh, Pa., was named as the 1956 recipient of the American Petroleum Institute's Gold Medal For Distinguished Achievement.

Drake

Drake was elected chairman of the board of Gulf in May, 1948, and five years later was named chairman of the Executive Committee.

A native New Englander, he is a graduate of Dartmouth College, where he received an honorary degree of Doctor of Laws in 1952. During his career in petroleum, Drake has been a member of the board of the American Petroleum Institute, and has served with the Petroleum Industry War Council, and the National Petroleum Council, as well as the National Industrial Conference Board, of which he was chairman from 1945 to 1947.

Armstrong

Menard

John B. Armstrong and **Harvey Menard** were recipients of the CNGA Award for Meritorious Service in 1956. This annual award recognizes outstanding service to the industry and CNGA by men under 43 years of age.

John B. Armstrong is Test Engineer for Natural Gasoline Operations, Producing Department, of the Standard Oil Company of California. He attended Ohio State University, receiving a Bachelor of Chemical Engineering degree in 1937 and a M.S. degree in 1938. In 1939 he went to California where he worked first, as a chemist for a pharmaceutical company and later as an engineer for a consulting metallurgical laboratory.

In 1945 he joined California Research Corporation as a research engineer. In 1948 he was transferred to the former Natural Gasoline department as test engineer for the southern district and in 1951 he was moved to his present position in Taft, California.

Armstrong is a Registered Professional Engineer in Chemical Engineering in California. He has been a member of the California Natural Gasoline Association Corrosion Committee since its formation and is current chairman of that committee.

Harvey Menard is the General Superintendent of the Gas Department with the Signal Oil and Gas Company. He joined Signal Oil and Gas Company in 1947, as gas engineer. He was advanced to process engineer until 1951, at which time he was made General Superintendent.

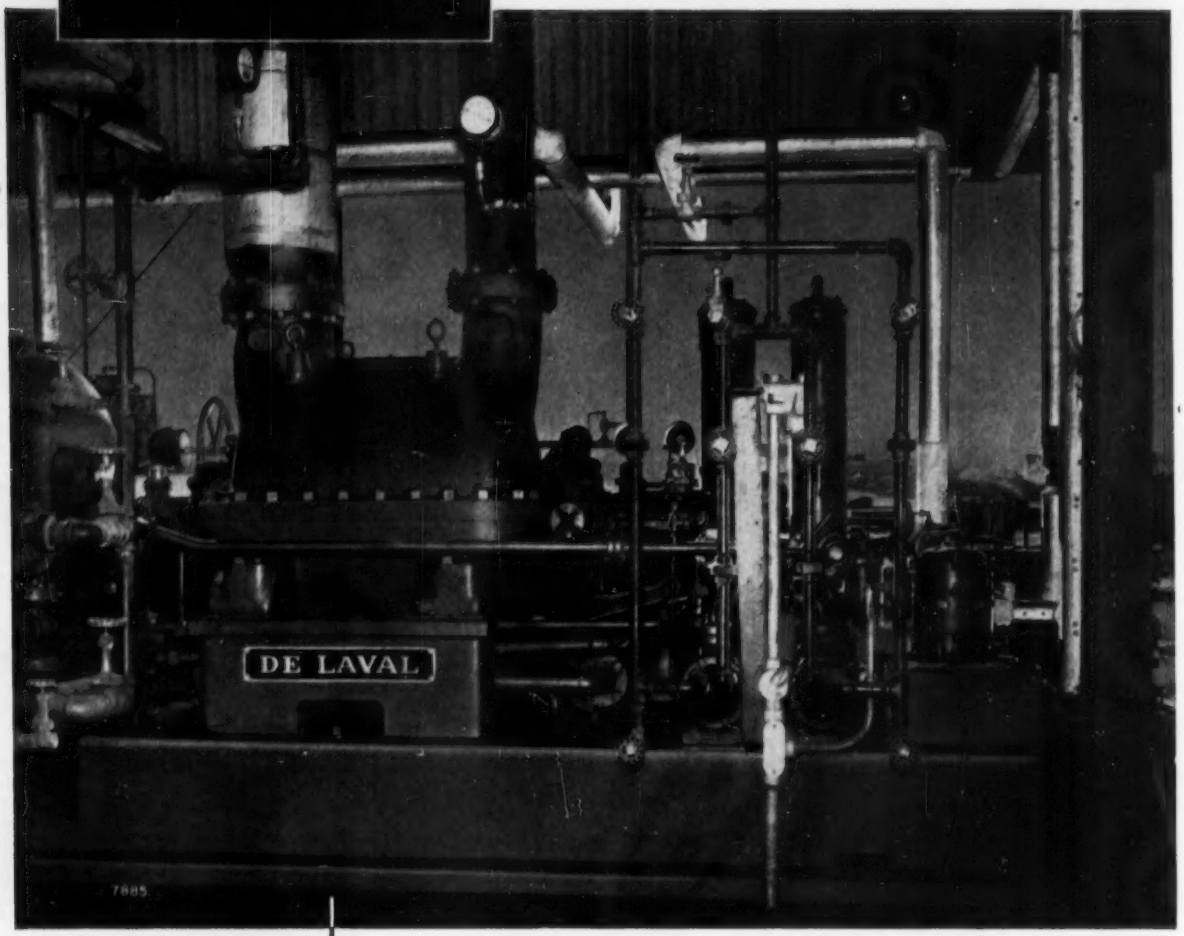
He is a graduate of the University of Washington where he received a B.S. degree in chemical engineering in 1943. Prior to his association with Signal Oil and Gas Company, Menard was employed as a process engineer with Bechtel McCone Parsons; as a sales engineer with Crosby Steam Gage and Valve; as a chief chemist with Ohio Oil Company; and as a fractional analyst and consultant in partnership with E. E. Shafer Laboratories.

His association with the CNGA has included work on many different committees and the Chairmanship of the LPG and Technical Committees.

A new award has been initiated this year by CNGA to be presented to outstanding old-timers as a "Service Award of Merit." The recipients for 1956 were W. L. Cowan, Union Oil Company of California; John C. Herron, Shell Oil Company; P. W. Hill, Signal Oil and Gas Company; Mark McIlvaine, Chanslor-

DE LAVAL
CENTRIFUGAL
COMPRESSOR

handles propane-butane for M. W. Kellogg alkylation unit



New Bulletin 0504 gives complete data

On stream at a plant of a large mid-western refiner, this De Laval unit compresses the propane-butane mixture to prepare it for an M. W. Kellogg alkylation unit.

Inlet volume of the De Laval centrifugal compressor is 3,040 cubic feet per minute. Inlet pressure is 18 psia, and discharge pressure 85 psia. This compressor is equipped with De Laval contact-type oil seals. The unit is driven by a 600 bhp turbine running at 7,400 rpm.

De Laval compressors are designed and built for heavy duty continuous operation. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings assure optimum performance and long service.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL 508

Men in the Industry . . .

Western Oil & Development Company; and E. P. Valby, Richfield Oil Corporation.

Dr. Herman C. Schutt, chemical engineering specialist, has been appointed technical consultant at Armour Research Foundation of Illinois Institute of Technology, Chicago. In this position, he will provide consultation on projects in the Foundation's chemistry and chemical engineering research department.

Richard T. Colquette, vice president of the Pan-Am Southern Corporation, New Orleans, has taken early retirement to Houston as vice president for refining of Crown Central Petroleum Corporation. **Karl W. Shimeall,** whom he succeeds, will become vice president in charge of Crown Central's southwestern operations, Houston.

John E. Swearingen and **Dr. Robert C. Gunness,** were elected executive vice presidents of Standard Oil Company (Indiana). Swearingen's primary responsibility will be the coordination of activities of affiliated companies with the parent company. Dr. Gunness will direct and coordinate the activities of the manufacturing, sales, and supply and transportation departments.

The retirement of **Dr. Max G. Paulus,** vice president in charge of manufacturing since 1933 and a director since 1932, after more than 41 years company service, was also announced. **Samuel A. Montgomery,** general manager of manufacturing and a director since 1951, was elected vice president to succeed Dr. Paulus.

John E. Ford, Jr., has been elected chairman of the board and chief executive officer of U. S. Oil & Refining Company. Ford, one of the original founders of the company, has been acting as Petroleum advisor to the company for the past 18 months.

Ford has been connected with Sinclair Refining Company, The M. W. Kellogg Company and Houdry Process Corporation for 20 years.

The new refinery U. S. Oil & Refining has under construction at Tacoma, Washington, is expected to go on stream this winter.

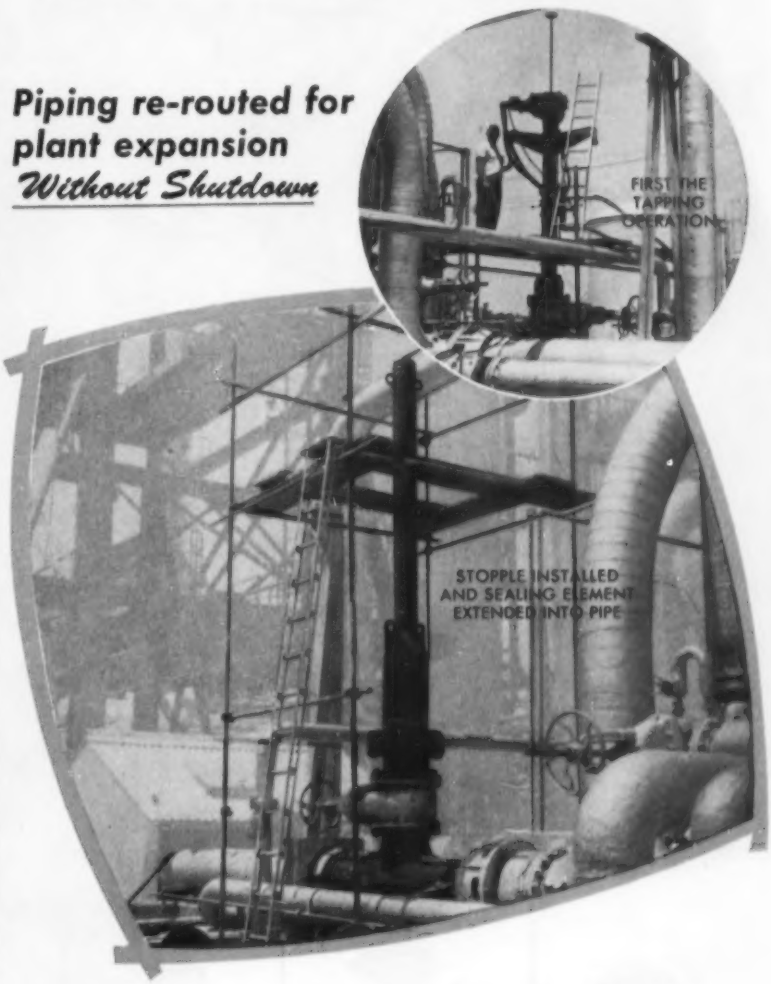
Eger V. Murphree, president of Esso Research and Engineering Company is taking one year's leave from the company to direct the nation's guided missle program. He is now special assistant to the Secretary of Defense Charles E. Wilson. Murphree has been with the Jersey Standard organization since 1930. He worked on the Manhattan Project during World War II.

Maurice B. Parmelee has been elected secretary-treasurer and a member of the board of directors of Sun Oil Company, Ltd. **Frank R. Markley** has resigned as a member of the board but will continue as vice president.

Donald J. Smith, president of the American Oil Company, received from **Dr. Robert E. Wilson,** chairman of the board of American and its parent company, Standard Oil Company (Indiana), a gold tie clasp with two diamonds in recognition of 40 years of company service. The presentation was made at a board of

ANOTHER PLANT AVOIDS SHUTDOWN

Piping re-routed for plant expansion Without Shutdown



Piping changes are made while flow continues through temporary by-pass around section sealed off by a pair of STOPPLES

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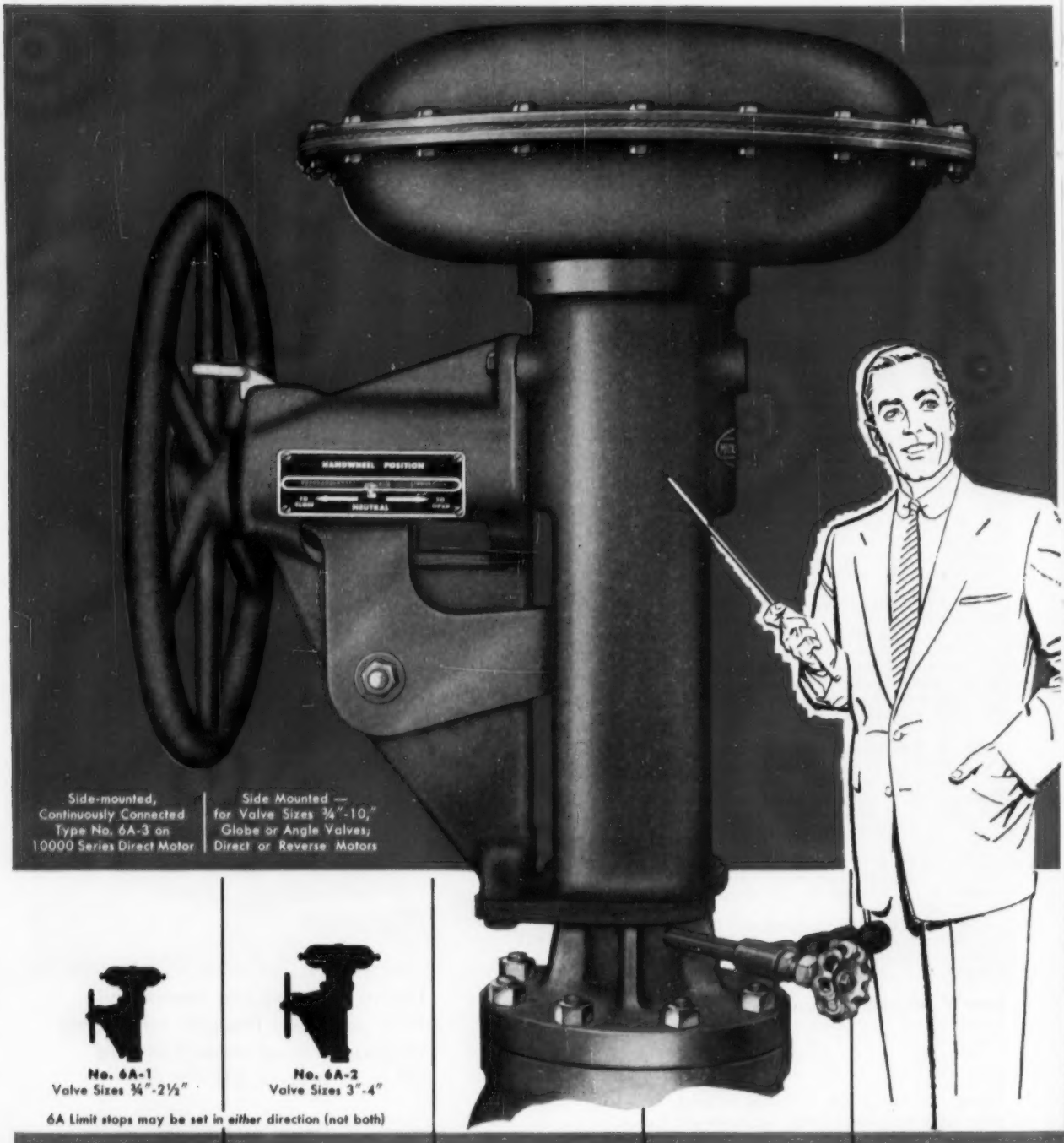


Side-mounted, Continuously Connected Type No. 6A-3 on 10000 Series Direct Motor

Side Mounted — for Valve Sizes ¾"-10," Globe or Angle Valves; Direct or Reverse Motors

No. 6A-1
Valve Sizes ¾"-2½"

No. 6A-2
Valve Sizes 3"-4"

6A Limit stops may be set in *either* direction (not both)

No. 2-9
Valve Sizes ½"-1½"
Direct Motor

No. 2-11
Valve Sizes 2"-2½"
Direct Motor

No. 2-13
Valve Sizes 3"-4"
Direct Motor

No. 3-15
Valve Size 6"
Direct Motor

No. 3-18
Valve Sizes 8"-10"
Direct Motor

Case Mounted — for Valve Sizes ½"-16", All Valve Types • Limit stops may be set in one direction only (upward travel)

Masoneilan Handwheels Available in 17 Models for Extra Safety

For Emergency Manual Operation . . . For Travel Limit Stops on Air Operated Control Valves

Handwheels provide vital safeguards wherever air failure might be costly in loss or process media or dangerous to plant and personnel. In these cases, provision for manual operation of the control valve is inexpensive insurance.

Mason-Neilan offers the widest available selection of handwheel equipped control valves to provide this extra measure of safety for such applications as . . .

- **Liquid or gas pipe lines**
- **Feed lines to process heaters**
- **Main process backpressure service, such as poly plant reactor outlets**
- **Critical liquid level control installations, especially ammonia let-down**

In addition, these handwheel units are equally useful in providing travel limit stops to insure . . .

- **Limiting minimum flow on gas fired units**
- **Limiting maximum flow on liquid level applications and similar installations**

The Masoneilan Handwheel is sturdily constructed and matched to the individual control valve to do the job for which it is designed, with a minimum of effort. For further information consult the office nearest you — or write . . .

MASON-NEILAN

Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASSACHUSETTS

MASONEILAN

Sales Offices or Distributors in the Following Cities: New York • Syracuse Chicago • St. Louis • Tulsa • Philadelphia • Houston • Pittsburgh Atlanta • Cleveland • Cincinnati • Kansas City • Phoenix • Detroit San Francisco • Louisville • Salt Lake City • El Paso • Albuquerque Charlotte • Los Angeles • Corpus Christi • Denver • Appleton Birmingham • New Orleans • Seattle Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

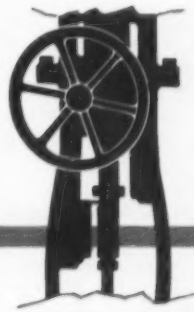
No. 6A-3
Valve Sizes 6"-10"
6A Limit stops may be set in *either* direction (not both)

No. 9-9
Valve Sizes ½"-1½"
Reverse Motor

No. 9-11
Valve Sizes 2"-2½"
Reverse Motor

No. 9-13
Valves Sizes 3"-4"
Reverse Motor

Limit stops may be set in *either* direction (not both)



Continuously Connected Gear Operated Type for Valve Sizes 12"-16", Globe or Angle Valves; Direct or Reverse Motors
No. 8-18, 8-24

Limit stops may be set in both directions.

No. 4-18
Valve Sizes 8"-10"
Direct Motor

No. 5-18
Valve Sizes 12"-16"
Direct Motor

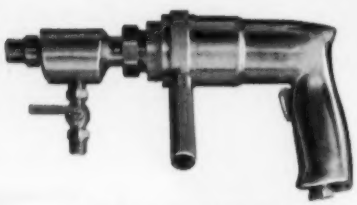
No. 6-18
Valve Sizes 12"-16"
Direct Motor

No. 7-24
Valve Sizes 12"-16"
Direct Motor

Case Mounted — for Valve Sizes ½"-16", All Valve Types • Limit stops may be set in one direction only (upward travel)

HEAT EXCHANGER TUBE CLEANER

- New light-weight, handy-to-use machine enables you to zip through the small tube cleaning chore in a jiffy.
- Powerful air-driven motor with attached non-rotating, water feeding attachment, trigger-action for motor control, finger-action valve for water flow to cool drill and flush tubes.
- Built-in speed governor eliminates shaft-whip caused by the excessive speed when not loaded.
- Built-in oil reservoir insures far longer life and less need for maintenance.
- Choice of two sizes. For details, contact your local Elliott representative or write Elliott Company, Springfield, Ohio.



ELLIOTT 512400
Heat Exchanger Tube Cleaner
Weight: 6½ lb — Length: 13 in

ELLIOTT 512300
Heat Exchanger Tube Cleaner
Weight: 5 lb — Length: 10½ in

16-4a

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

Men in the Industry . . .

directors luncheon. Smith began his service in 1916 at the Indiana company's refinery at Whiting, Ind., and during his career has directed the construction of four major refineries. He has held executive positions in the company since 1933.

W. A. Wilson has been appointed plant manager of the new Orange, Texas, butadiene plant of The Firestone Tire & Rubber Company.

Wilson was technical manager of Firestone's Lake Charles, Louisiana, synthetic rubber plant for eight years during World War II and during the postwar period. Since 1951 he has worked in Akron as a special assistant on the company's petrochemical program.

Claud B. Barrett has been elected a director of The Texas Company. Barrett is a vice president in the Houston office and was formerly vice president in charge of domestic sales.

Richard W. KixMiller will succeed **Charles F. Beran** who is retiring as a director of Celanese Corporation of America, following 33 years' association with the company. KixMiller is vice president in charge of the Celanese Chemical Division.

Kix Miller

Beran's association with Dr. Camille Dreyfus who, with his late brother, Dr. Henri Dreyfus, founded the Celanese enterprise, dates back to 1916.

As chief engineer of the company, which he joined in 1923, Beran helped direct construction of the first Celanese plant in Cumberland, Md. In 1939, he became vice president in charge of plant construction and maintenance and in 1942 was named vice president in charge of production. He has been a director since 1938.

KixMiller has been with the Celanese organization since 1946 and vice president in charge of the Chemical Division since 1955. During World War II Navy service, he was assigned to the Rubber Reserve program as assistant manager of research and development in connection with the government's synthetic rubber program. A 1942 Princeton University graduate, he is a resident of Summit, N. J.

Thomas P. Turchan has been appointed assistant general manager, Industrial Chemicals division, American Cyanamid Company.

Prior to this appointment, Turchan was manager of manufacturing of the company's Agricultural Chemicals division. He joined Cyanamid at the Niagara Falls, Ontario, plant where he was subsequently appointed plant manager.

A metallurgical engineer with a degree from Colorado School of Mines, Turchan spent three years in the Philippines as mining engineer and general superintendent of Catanduanes Gold Mines Company, Manila. He returned to the United States in 1938 as a sales engineer and mine foreman until 1941. Then he became associated with Basic Magnesium, Inc., Henderson, Nevada, where he was made plant super-

For more data on advertised products, use Readers' Service Cards, last page.

Another client benefits from a Badger "Precious Plus"

An Achievement of Creative Engineering:

STYRENE FROM GASOLINE!

Sketch shows Cosden Petroleum's new ultra-fractionation and styrene manufacturing plant as it will appear when completed in early 1957. The four columns — each almost 200 feet high —will be among the tallest ever erected!

The plant that "couldn't be built" now under construction

At Cosden's Big Spring, Texas, refinery, Badger is erecting the first plant ever designed for the recovery of ethyl benzene by distillation. The process *first* became commercially practical when Badger Engineers developed Ultra-fractionation.

Now, instead of marketing catalytic reformer effluents as mixed solvents, this new distillation process will make it possible for the client to produce a pure product with a far higher profit margin.

This achievement in *Creative Engineering**, like all intangibles, can never be shown on the blueprints. Yet it is the "Precious Plus" in Badger's performance that is making Cosden's plant possible!

Other leading companies, too, find Badger's *plus* in performance of precious advantage — whether their need is design, engineering or construction. How else explain the unusual growth Badger is enjoying?

+ You need new "yardsticks" to measure the plus performance of Badger. For the abilities of this dynamic organization go far beyond what can be shown on blueprints—and it's such intangibles that add up to better processes and plants, faster and at lower cost.

*Creative engineering . . . whether your process problem is common or complex, Badger engineers solve it with fresh thinking that frequently produces new efficiencies, unexpected savings.

Broad experience . . . Badger Engineers are more than competent—most staff members are recognized authorities in their fields.

Key Man operation . . . the Badger man who submits your proposal is always a principal—always the Key Man responsible for the execution of your job. Clients say, "This is the Badger difference that makes the difference."

BMC

BADGER MANUFACTURING COMPANY

230 Bent Street, Cambridge 41, Massachusetts
60 East 42nd Street, New York 17, New York
In Europe: Badger-Comprimo N. V., The Hague, Holland

ENGINEERS • CONTRACTORS • DESIGNERS • MANUFACTURERS

Men in the Industry . . .

intendent. Later he became an engineering consultant with American and British chemical firms. Before joining Cyanamid, he was works manager for Stauffer Chemical Company at Niagara Falls, New York.

E. Finley Carter has been appointed as director of Stanford Research Institute, and has also been named to the Institute's board of directors.

The new chief executive of the applied research center joined SRI in 1954 as manager of research operations. Upon the resignation of Dr. J. E. Hobson, the Institute's head for eight years, last December, Mr. Carter was named associate director and since then has been responsible for over-all direction of the Institute's activities.

Dr. V. A. Kalichevsky, recent ACS Southwest award winner, has been elected Fellow of the American Association For The Advancement of Science. Dr. Kalichevsky was presented the AAAS scroll as official recognition of the honor.

A. T. Maasberg, who has been technical director of plastics production for the past two years, has been appointed director of research and development for The Dow Chemical Company's Midland division. **Arthur F. Roche,** assistant director of the Plastics Production Laboratory, has been named to succeed Maasberg.

Maasberg, a 20-year Dow veteran, came to the company in 1936 as a chemist in the Cellulose semi-plant after graduation from Syracuse University with a degree in cellulose chemistry.

H. C. Lyles has been promoted to general foreman of Utilities Department at Humble Oil & Refining Company's Baytown, Texas, refinery. He holds the B.S. degree in electrical engineering from Louisiana State University, and has been at Baytown Refinery since 1939. He has served twice in Humble's executive development program, as assistant powerhouse and boilerhouse foreman, and as utilities foreman at one of the rubber plants.

Wallace E. Avery has been elected secretary of The Texas Company, succeeding **Walter G. Elicker,** who has retired after 38 years service. Avery, previously assistant secretary, has been with Texaco since 1945 when he joined the company as an attorney in the Los Angeles office. He was assistant chief counsel for the PAW in Washington during World War II.

Bruce K. Brown, New Orleans, has been elected by the Board of Directors of Petroleum Chemicals, Inc., as president and chief executive officer. Brown was former deputy administrator of the Petroleum Administration for Defense, and until recently, president of Pan-Am Southern Corporation.

Brown

Petroleum Chemicals, Inc., jointly owned by Cities Service Company and Continental Oil Company, has headquarters in New Orleans. At the meeting of the company's directors, **W. Alton Jones,** chairman of Cities Service Company, and **L. F. McCollum,** president of Continental Oil Company, resigned as chairman and president respectively of Petroleum Chemicals, Inc., thus placing Brown in the position of chief executive officer.

Robert F. Neal, of Magnolia Petroleum Company's marketing division at Dallas, has been appointed assistant manager of the Chicago division of Socony Mobil Oil Company, Inc. Magnolia is the southwestern affiliate of Socony Mobil.

A native of Carthage, Texas, Neal graduated from the University of Texas in 1931 with a B.S. degree in mechanical engineering. He began his career with Magnolia in 1934, as a gas well and meter inspector for the natural gas department. After six years service in oil fields in Texas and Oklahoma, he was transferred to the marketing division and placed in charge of marine sales at New Orleans.

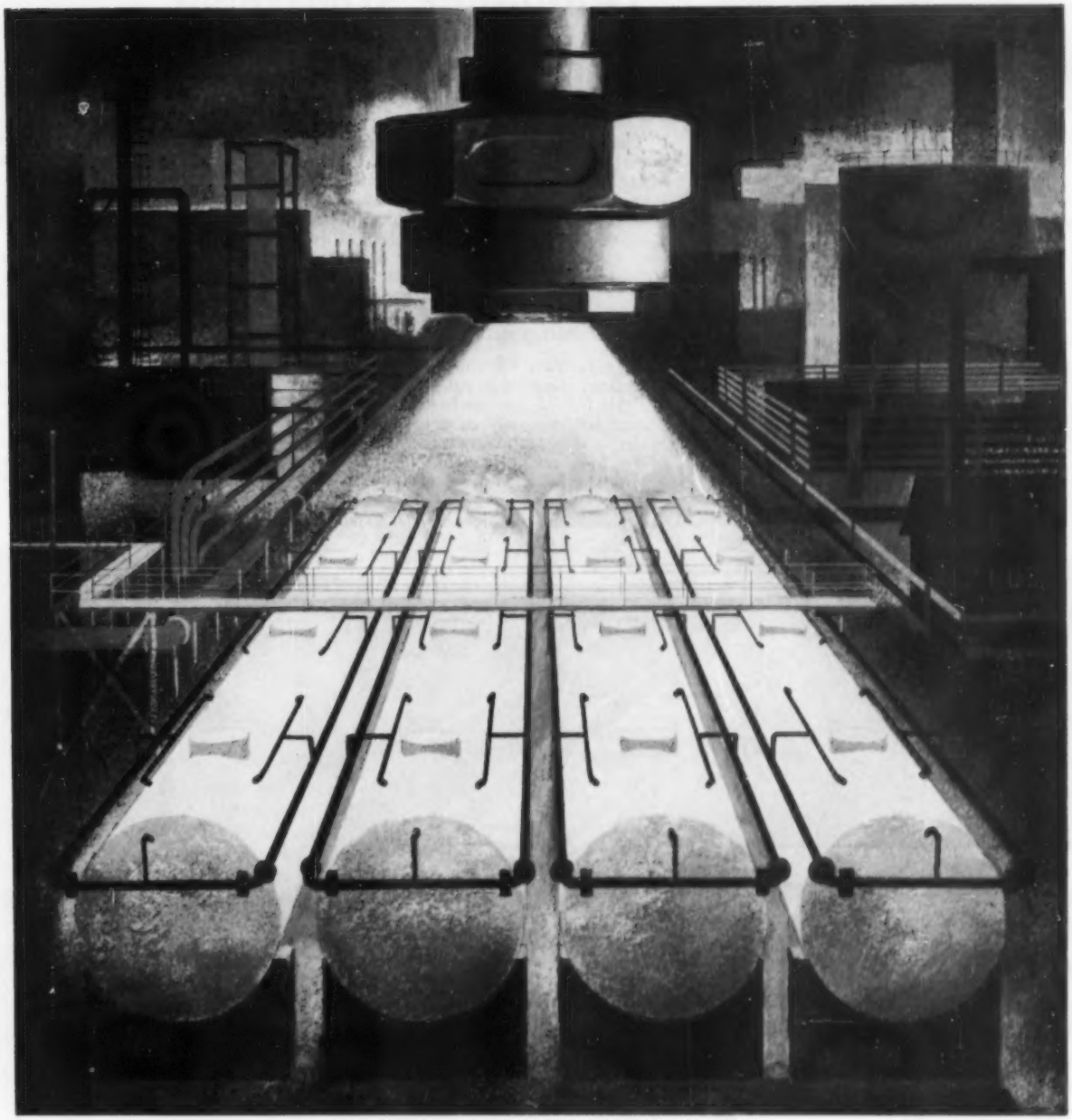
In 1946, Neal was made engine builders representative and brought in to Magnolia's general offices in Dallas. He was appointed a management assistant in 1950, and in 1952, was advanced to assistant to the vice president in charge of marketing.

R. D. Rogers, vice president and executive assistant to the eastern division general manager of Tidewater Oil Company, has retired following more than 36 years of service.

Rogers joined Tidewater in 1920 as chief engineer of refineries and natural gas plants of the subsidiary Tidal Refining Company at Tulsa, Oklahoma. In 1925, he

ARCCO
LIQUID GRAVITOMETERS
NOW 19 MODELS
MODEL RES
ARCCO—Anubis
For RECORDING, SIGNALLING
TRANSMITTING and CONTROLLING
For pipelines, refineries, chemical plants, etc., ARCCO Anubis Liquid Gravitometers are ruggedly built for hard field usage yet are accurate in performance as a laboratory instrument.
Temperature corrected, these extremely accurate instruments are adaptable to high pressures and are available with internal parts suitable for practically all corrosive liquids.
Send for Bulletin No. 111R-3.
AVAILABLE FOR EARLY DELIVERY
AMERICAN
RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
Send for Bulletin 111R-3

For more data on advertised products, use Readers' Service Cards, last page.



give your plant and equipment the best fire protection— a BLAW-KNOX automatic fog system

BLAW-KNOX Automatic Fire Protection Systems are engineered to provide positive protection for your plant and processing, storage, and other equipment. If a fire breaks out, the system goes into action immediately:

- **alarms sound**
- **fire smothered *promptly***
- **heat dissipated by *cooling* action**
- **pressure build-up prevented**

Why not give your plant and equipment the BEST possible protection. Let a Blaw-Knox *fire-protection* Engineer study your needs. He will gladly submit a layout and a cost estimate . . . with no obligation to you.

"Little Joey Sprinkler always on the job"

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY
Automatic Sprinkler Department
Pittsburgh 33, Pennsylvania

For more data on advertised products, use Readers' Service Cards, last page.

The exterior stairway and platform on this 100,000-barrel Texas Company storage tank have treads of Multigrip Floor Plate. Their evenly-spaced, flat-topped risers offer positive traction, even when wet.

As the floating roof rises, a cam attachment on this stair-ramp lowers one end of each stair tread, thus converting the stairway into a ramp. The stair treads are made of Multigrip Floor Plate.

Two-in-one stair-ramp made non-slip with Multigrip

THE GIANT 100,000-barrel storage tanks at The Texas Company's Port Arthur tank farm have roofs that float up and down. As the fluid level of a tank moves, the roof moves with it, thereby reducing evaporation. To make the shifting roofs accessible from above, The Texas Company installed ingenious stair-ramps. The footing surface of each stair-ramp is made of narrow sections of USS Multigrip Floor Plate.

Stair-ramps are so named because of a cam control which converts the walking surface from ramp to stairway, depending on the height of the floating roof. As a tank empties, the roof sinks, increasing the ramp's angle. When the angle becomes severe, the cam attachment raises one end of each ramp section, thus converting it to a step, automatically.

Safe-Lasting—Footing on every stair-ramp is important. To guard against slipping accidents, The Texas Company chose Multigrip Floor Plate for the foot surfaces. The clean-edged, flat-topped risers give sure-grip traction—wet or dry. Multigrip can be cut, shaped or formed with ease and it stands up under rugged use, year after year. Follow the practice of oil companies all over the country, count on Multigrip Floor Plate wherever safe footing, long wear and low maintenance are important.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, CHICAGO
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

Close-up view shows why Multigrip's evenly-spaced, flat-topped risers provide all-weather traction on this storage tank stair-ramp.

USS **multigrip**

FLOOR PLATE

Sold by leading distributors from coast to coast

6-2662

UNITED STATES STEEL

Men in the Industry...

became general superintendent of the company's eastern division refinery, formerly located at Bayonne, New Jersey. In 1933, he was made manager of operations of the sales department at the divisional office in New York. He became assistant general sales manager in 1946, and in 1953 was named manager of the divisional transportation and supply. Rogers was later named vice president and vice chairman of the eastern division operating committee.

Rogers will continue to serve the eastern division of the company in a consulting capacity.

T. M. Kerr, formerly executive vice president of Kerr-McGee Oil Industries, Inc., has been elected vice chairman of the board of directors.

Other elections within the company also were announced. **F. C. Love,** formerly general vice president, will become executive vice president. **A. T. F. Seale,** formerly vice president of manufacturing, will become vice president of operations. **W. M. Murray** has been named vice president of general sales, **R. M. Chesney** vice president of refining, and **J. W. Roach** vice president of crude oil supply, pipelines, and refinery technical services.

Elliott

Ramsey

Lloyd W. Elliott has been elected to the executive committee of Standard Oil Company (New Jersey) and **Dyer W. Ramsey, Jr.,** has been appointed coordinator of the company's worldwide marketing activities.

Elliott, a vice president and director of Jersey Standard, was president of Standard-Vacuum Oil Company when he was elected to the Jersey board of directors in 1951.

Ramsey joined the Jersey organization in 1928 and after successive promotions was appointed deputy marketing coordinator in 1954. He succeeds **William R. Stott** who was recently elected a director.

Dr. Adalbert Farkas, section chief in exploratory research at Houdry Process Corporation, has been elected to the board of directors of the newly-organized International Congress on Catalysis.

Farkas was a member of the planning committee and the board of directors of the First International Congress on Catalysis held last month in Philadelphia. He is also chairman of the budget and finance committee of the Philadelphia section of the American Chemical Society, and a member of the Chemical Society and the Faraday Society of London, the Catalysis Club of Philadelphia, and the Organic Chemists Club.

Harry L. Arnold has been named to the law department of Standard Oil Company (New Jersey). He has been an attorney in the Tulsa office of Carter Oil

BS&B Safety Heads
SOLVED THE PROBLEM!

No. 2 of a series

CASE HISTORY FILE NO. 1291

Problem:

A large refinery was piping products to storage, with a single supply line serving two or more tanks. Pressure protection was needed for the piping in the event that valves were inadvertently left in a closed position.

Solution:

BS&B Safety Heads with 10" lead-lined aluminum rupture discs were installed on all product lines to storage tanks.

Result:

These Safety Heads will provide safe, instantaneous relief from overpressure in the lines whenever the critical pressure is reached. This application is now covered by an Engineering Standard from subject company's home office.

BS&B — Another Example of Product Leadership

Have you considered what BS&B Safety Heads can do to improve the safety of **your** pressurized equipment? Complete information on the many possible applications of BS&B Safety Heads will be sent on request.

THE "CIRCUIT-BREAKER" of Pressured Systems

BLACK, SIVALLS & BRYSON, INC.
Safety Head Division, Dept. 2-F11
7500 East 12th Street Kansas City 26, Missouri

For more data on advertised products, use Readers' Service Cards, last page.

GIANT

TIDEWATER REFINERY

PROTECTED

by Consolidated Safety Relief Valves

FLYING A SERVICE

The world's most modern refinery will soon go on stream. It is the gigantic Delaware Flying A Refinery of the Tidewater Oil Company just 15 miles south of Wilmington. C. F. Braun & Co., engineering contractors, built the new plant on the 5000-acre site. Many of the processing units are unequalled for size and capacity anywhere. In around-the-clock operation, 130,000 barrels of crude of any kind can be processed daily. Tidewater engineers incorporated the most advanced design and equipment to provide the greatest flexibility, economy and safety.

Consolidated Safety Relief Valves are "sentinels of safety" in this mammoth "refinery of the future". Peak performance and consistently positive valve action are assured even where discharge lines are long or there is low "superimposed" back pressure in the relieving system. They provide the absolute protection so vital in petroleum processing and on product storage facilities.

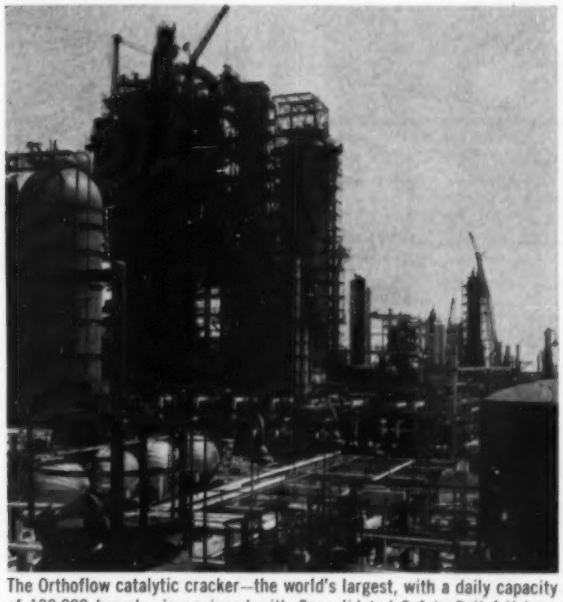
Wherever Consolidated Safety Relief Valves are used, flexibility of application greatly reduces inventory costs. They are "2 in 1" valves. Interchangeability is so highly perfected that you can convert the Standard type to the Balanced Bellows Seal type *in the field* simply by installing a stainless steel sealing bellows. You can readily interchange these valves with those of other manufacturers: inlet and outlet center-to-face dimensions are standardized. Consolidated Safety Relief Valves also have fewer functional parts than comparable valves. The seating surface is optically-ground flat. From every standpoint, you can count on lower inventory costs and easy maintenance.

Write for full details about the complete reliability and all-around economy of Consolidated Safety Relief Valves. Both Standard and Bellows type are available in sizes and pressures to meet requirements today and tomorrow. Ask for Catalog 1900.

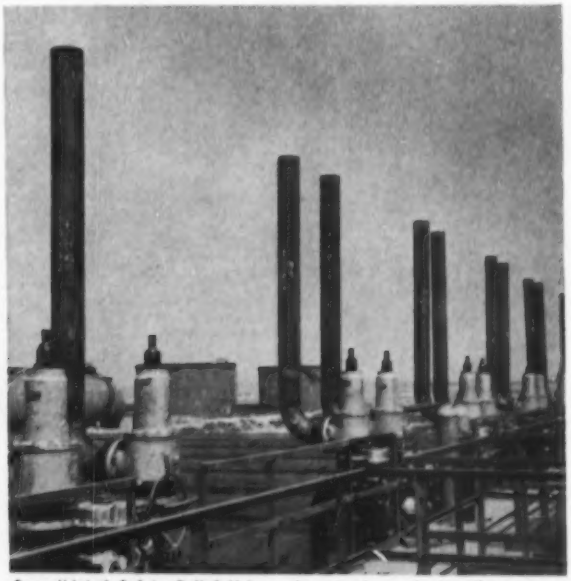
CONSOLIDATED SAFETY RELIEF VALVES

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

Tidewater Oil Company's "refinery of the future" has required nearly 7000 men in its construction. The enormous size of the installation can be gauged by the 500-foot high power station stack at the extreme left. To the right of the stack are, in order, the fluid coker, the sulphur recovery plant, the crude unit, the Orthoflow fluid catalytic cracker and other processing units. The Delaware Flying A Refinery's 7,000,000 barrel capacity "tank farm" is in the background. The refinery's processing units occupy 450 acres of the 5,000-acre site.



The Orthoflow catalytic cracker—the world's largest, with a daily capacity of 102,000 barrels—is equipped with Consolidated Safety Relief Valves.



Consolidated Safety Relief Valves also stand guard atop the propane storage bullets at Tidewater's Delaware Flying A Refinery.

CONSOLIDATED 1879 U.S.A.

MAXWELL MANNING MOORE INC. TRADE MARK

A PRODUCT OF MANNING, MAXWELL & MOORE, INC.

TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.*, 'HANCOCK' VALVES, *Watertown, Mass.*, 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.*, AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.*, "SHAW-BOX" AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.* **In Canada:** *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.*

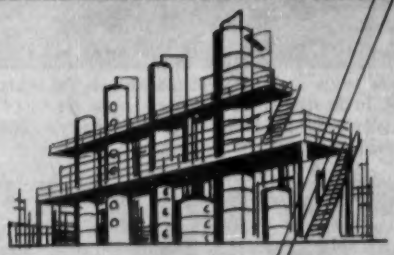
For more data on advertised products, use Readers' Service Cards, last page.

Vulcan designs

FLUID BED REACTORS

For Catalytic Chemical Reactions involving

HIGH HEAT RELEASE or HEAT ABSORPTION



Can the many advantages of fluid bed processing be brought to your chemical plant operations? Vulcan Engineering Division's fluid bed techniques are ideally suited to those reactions accompanied by release or absorption of large quantities of heat in which precise control of temperature is a primary requisite.

These techniques can be utilized to considerable advantage in effecting component transfer from gas to solid (absorption), chemical reaction of solid and gas (such as ore reduction) and gaseous, vapor or liquid reactions in the presence of solid catalysts (for example, oxidation reactions).

Vulcan's new Fluid Bed Reactors offer these advantages: Uniform operating conditions; consistent yields; maintenance of catalyst activity; simple heat recovery and safety of operation.

Vulcan's engineering experience in developing and designing processes for chemical and petrochemical plant operations . . . including extensive pilot plant work in its own laboratories in both glass and metal apparatus . . . can be applied to the adaptation of fluid bed techniques to your unique processing problems. We invite your inquiry.

VULCAN ENGINEERING DIVISION

VULCAN-Cincinnati, Inc.

(Formerly THE VULCAN COPPER & SUPPLY CO.)

General Offices and Plant, CINCINNATI 2, OHIO

BOSTON CHARLOTTE N. C. DENVER HOUSTON SAN FRANCISCO

VICKERS VULCAN PROCESS ENGINEERING CO., LTD., MONTREAL, CANADA

DIVISIONS OF VULCAN, CINCINNATI, INC.

VULCAN ENGINEERING DIVISION • VULCAN MANUFACTURING DIVISION • VULCAN CONSTRUCTION DIVISION

Men in the Industry...

Company during the past ten years. He joined Carter in 1946 after having served as assistant attorney general of Illinois.

Robert O. Brown has been promoted to manager of engineering and construction for the marketing department of American Oil Company. He succeeds **George E. Blatchley** who retired recently.

Brown joined Standard Oil Company (Indiana), parent company of American, in June, 1937, as an assistant construction superintendent at Mason City, Iowa. He held other engineering positions with Standard at Huron, S. D., and Green Bay, Wis., before being transferred to the Chicago Sales Division in 1951 as superintendent of construction and maintenance. He was transferred to American in New York in December, 1955, as assistant chief engineer and held that position until his present appointment.

J. B. Balmer, president, John Wood Company, N. Y., was elected a director of the American Gas Association at the 38th Annual Convention of the Association in Atlantic City, N. J. Balmer was elected for a two-year term expiring in October, 1958.

Balmer

The American Gas Association is the national trade association of the seventeen and one-half billion dollars gas industry. More than 4000 delegates, representing every branch of the gas industry, and hailing from nearly every state in the nation, attended the three-day meeting.

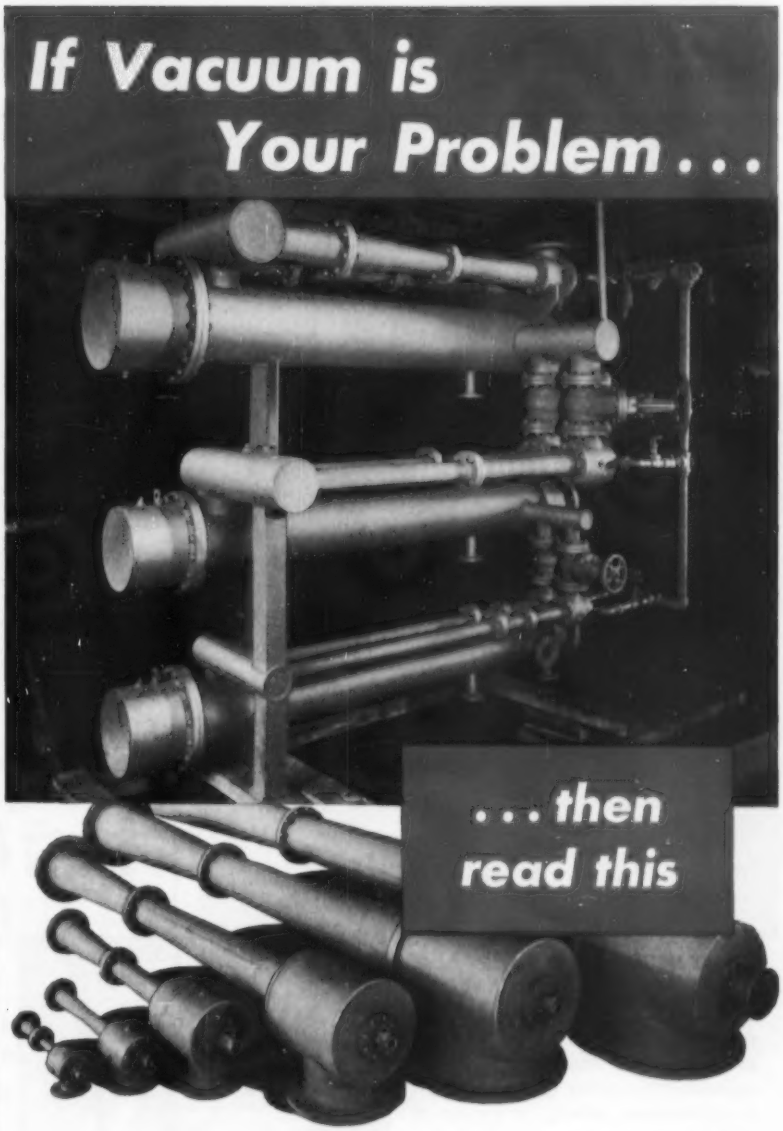
Earl W. Russell has been elected secretary of Standard Oil Company (Indiana) to succeed **Laban E. Harmon,** who has retired after more than 34 years with the company.

Russell, who has been executive assistant secretary, joined Standard in 1928 as a clerk in the Indianapolis, Ind., sales division. In 1938 he was transferred as an analyst to the sales research department in the company's general office at Chicago. In 1942 he became office manager of that department. He was appointed administrative assistant in the president's office in 1946. In 1952 he was elected assistant secretary and in 1955 was advanced to executive assistant secretary.

Harmon joined Standard in 1922 as an accountant in the manufacturing accounting department. He became assistant auditor of manufacturing in 1924, assistant general auditor in 1928, and auditor of manufacturing in 1929. He was elected assistant secretary of the company in 1931 and secretary in 1945.

F. Cushing Smith has been named general manager of the supply and transportation department of Standard Oil Company (Indiana).

Smith will direct and coordinate the distribution economics, operations, purchasing, and traffic departments. He will fill the vacancy created recently when **Dr. Robert C. Gunness** was promoted to executive vice president to direct and coordinate operations of the company's manufac-



We believe we are the largest manufacturers of Steam Jet Ejectors in the world. Our volume of business points to the fact that Graham Ejectors have always performed in the manner predicted—and industry has shown its confidence by generally preferring Graham. Remember the old saying "50 million Frenchmen can't be wrong".

We are constantly improving our product. Therefore, if you buy "Graham" you are certain of the most modern vacuum producing equipment money can buy.

Send your next inquiry to our nearest office—without obligation. We offer you a thorough engineering analysis, resulting in properly selected equipment—at competitive prices and good deliveries.

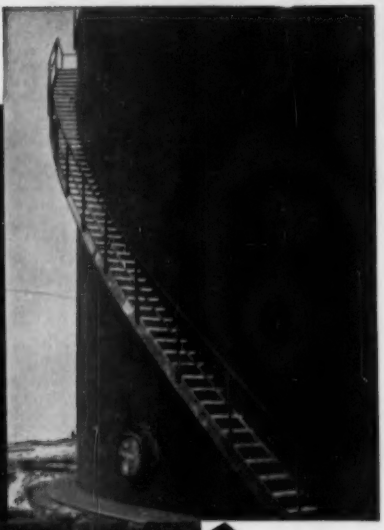
Graham

MANUFACTURING CO., INC.
415 LEXINGTON AVE., NEW YORK 17, N. Y.
Offices in all principal cities

For more data on advertised products, use Readers' Service Cards, last page.

Use SAFETY GRIP-STRUT grating

Wherever a safe footing is required



Grip-Strut circular stairway on Shell Oil tank in Portland, Ore.

See how Shell Oil uses Grip-Strut for a safe ramp between tanks.

View looking down circular stairway on Shell Oil tank shown above.

SAFETY GRIP-STRUT is the new basic material, all in one piece (including channels), not welded, riveted or expanded in steel or aluminum, in standard sizes and gauges. Safety GRIP-STRUT presents an open space, in a diamond pattern, in excess of 55% of the area for ready access of light and air and gives a positive NON-SKID footing in all directions. Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

Important Safety Features

- ★ Fire proof
- ★ Slip proof
- ★ Maximum strength
- ★ Minimum weight
- ★ Easy to stand on
- ★ Cool in summer—warm in winter

Pat. Pending

Write for new complete catalog.
Distributors in all principal cities.
Consult yellow pages in phone book under "GRATING"

GRIP-STRUT division
THE GLOBE COMPANY • *Manufacturers since 1914*
4008 S. PRINCETON AVE. • CHICAGO 9, ILL.

Men in the Industry . . .

turing, sales, and supply and transportation departments.

Smith is a graduate of Cornell University and joined Standard Oil in 1943 as a chemical engineer at Whiting, Ind.

H. P. Schorck, a director and treasurer of Standard Oil Company (New Jersey) has been named to the new post of executive development coordinator to assist the board of directors. He has been with Jersey Standard since 1917.

Parker C. Folse, safety director of Magnolia Petroleum Company's Refining Division, Beaumont, Texas, has been selected by Socony Mobil Oil Company, Inc., to assist in directing its accident and fire prevention efforts.

Folse

The new position will involve accident and fire prevention in all divisions—refining, producing, exploration, marketing and pipe line—of the corporation and its affiliates, including all foreign operations.

Folse is to specialize in studying fire causes and fire extinguishing methods throughout the petroleum industry and will also work with the engineering design section to develop the safest equipment possible for personnel in all divisions of the company.

Lloyd G. Smith, vice president and director of Creole Petroleum Corporation, retired after 43 years service. He started his career in 1913 as a draftsman at the Whiting Refinery of Standard Oil Company (Indiana), transferred to Casper, Wyoming in 1922 as a foreman. Later he fulfilled several posts with Pan American Petroleum and Transport Company and became part of the Standard Oil Company (New Jersey) organization when Pan American's foreign properties were bought by Jersey in 1932.

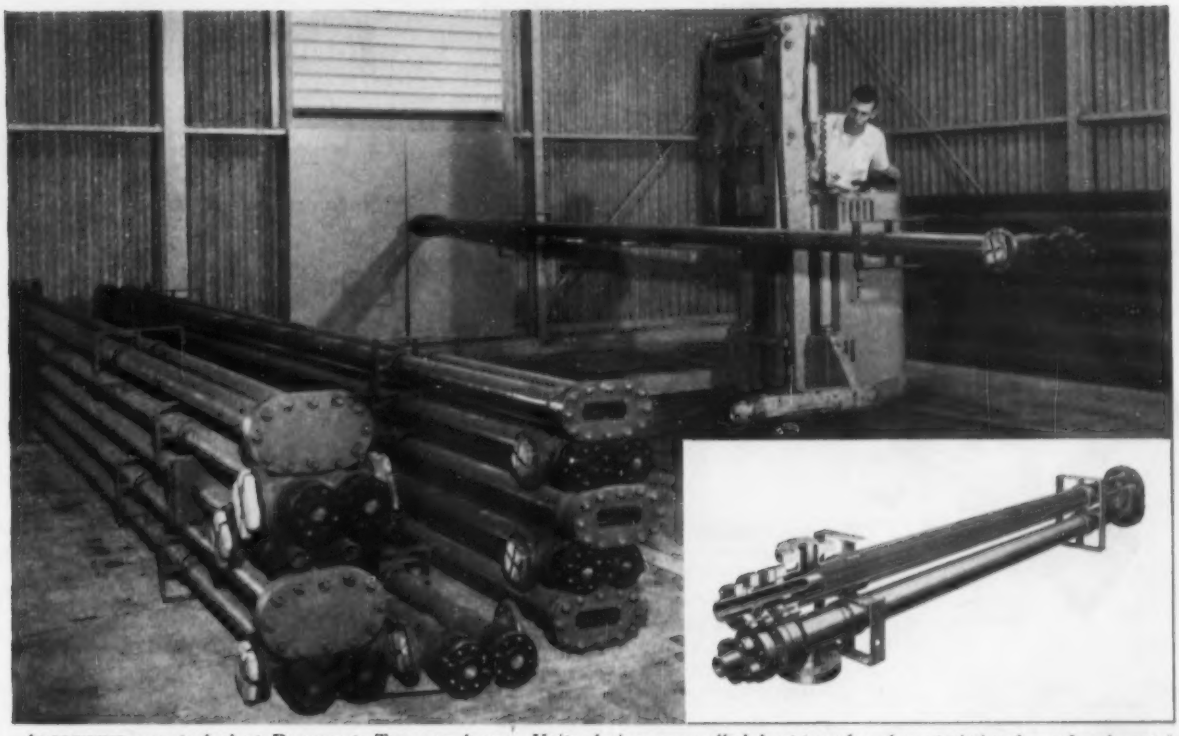
Harvey Cash has been named assistant to the chairman of The Texas Company. He was promoted to his new post after having been general manager of Texaco's foreign operations department, Eastern Hemisphere, since April 1954. Cash joined The Texas Company in 1933.

George H. Freyermuch has been elected chairman of the board of Esso Export, Ltd. and Standard Oil International Ltd., in London. Both companies are international marketing and supply affiliates of Standard Oil Company (New Jersey). Freyermuch has been with Jersey Standard companies for 28 years.

T. H. Tonnessen has been named assistant to the treasurer of Standard Oil Company (New Jersey). **V. J. Motto** becomes finance manager and **T. R. Lilley** was appointed investment manager.

Wilburn T. Askew has been elected president of Sun Oil Company Ltd. of Canada, succeeding **Joseph N. Pew, Jr.,** chairman of the parent concern, Sun Oil Company. Askew will be headquartered at the Canadian firm's offices at 85 Bloor Street East, Toronto. He was until re-

For more data on advertised products, use Readers' Service Cards, last page.



ALCOTWINS are stocked at Beaumont, Tex., warehouse. Units derive unequalled heat-transfer characteristics from fused metal-to-metal bond between the "U" shaped fin channels and the tube. ALCO's heliarc weld provides efficient, continuous bond.

NOW FIN TUBE ALCOTWIN® EXCHANGERS CAN BE BOUGHT "OFF THE SHELF"

ALCOTWIN Units, In Many Combinations of Tube and Fin Materials, Are Stocked In New ALCO Beaumont Warehouse for Immediate Delivery

For most process applications you'll find ALCOTWIN heat exchangers in stock right now at ALCO's new Beaumont, Tex., warehouse. "Off-the-shelf" purchase of these highly versatile units can materially lower your costs in revamping processes or in building for new processes.

Many combinations of tube and fin materials are in stock. ALCOTWIN standard parts, in almost every material, are available for high-pressure and high-temperature combinations—resulting in real economy in special services.

Building-block flexibility of the ALCOTWIN units can be used to meet your present process conditions, and future load and process requirements can be accommodated easily by rearranging units.

Look into the ALCOTWIN. ALCO sales offices, and Power Machinery Corporation offices in the Southwest, have complete information. Or write P. O. Box 1065, Schenectady 1, N. Y., for brochure.

ALCO

ALCO PRODUCTS, INC.
New York

ALCOTWIN Sales Agents: Power Machinery Corp.

Locomotives • Diesel Engines • Nuclear Reactors • Heat Exchangers • Springs • Steel Pipe • Forgings • Weldments • Oil-Field Equipment

For more data on advertised products, use Readers' Service Cards, last page.

BEFORE YOU SAY,
"IT CAN'T BE CAST"
...call an
ESCO engineer!

ESCO SHELLCAST carbon steel conveyor link.

ESCO SHELLCAST Valve Linkage Levers. Alloy steel Type 317, A296-49T CF-8M.

ESCO SHELLCAST Heat-treating Vane tip. Alloy steel Type 302B, A297-49T HF.

ESCO alloy steel castings can make your designing *easier.* You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time—

PLUS **Metallurgical Engineering and Research.** *ESCO* maintains one of the largest and best equipped metallurgical staffs of any alloy steel foundry—

PLUS **Product Engineering and Design.** An integrated service at all levels; in the field, at the drawing board and in the foundry—

PLUS **Foundry Facilities and Casting Experience.** A casting service that covers the complete range of alloy steel casting methods for all applications—

PLUS **Laboratory Inspection and Testing.** *ESCO* laboratory technicians are qualified and equipped to perform all types of inspections and testing to the most rigid specifications.

Call an *ESCO* Engineer—let him show you how *ESCO* Alloy Steel Castings make your designing easier.

Write today for your *FREE* copy of this informative 100-page reference book—"*ESCO* Alloy and Stainless Steels for the Process and Manufacturing Industries".

ELECTRIC STEEL FOUNDRY COMPANY

ESCO

Manufacturing Plants
2164 N.W. 25th Ave., Portland 10, Oregon
1017 Griggs Street Danville, Illinois

ESCO International and Eastern Sales
420 Lexington Ave., New York City, N.Y.
Other Offices and Warehouses
Los Angeles, San Francisco, Calif.; Seattle, Spokane, Wash.; Salt Lake City, Utah; Denver, Colo.; Houston, Texas; Centralia, Pa.; Eugene, Ore.; Honolulu, Hawaii

In Canada, ESCO Limited
Manufacturing Plants
Vancouver, B.C., and Toronto, Ontario.

Men in the Industry...

cently manager of the Marcus Hook, Pa., refinery. Askew is thus the first resident president of the Canadian firm, after 25 years with the parent firm.

Norman Hardy, vice president of Arabian American Oil Company, has been elected executive vice president. He started his oil business career in 1926 as a geologist with Standard Oil Company of California, served in several overseas and domestic posts until he joined Aramco in 1951. Hardy continues his location at Dhahran, Saudi Arabia.

M. A. Ellsworth, vice president and general manager, engineering and construction division, The Fluor Corporation, Ltd., has been named to Fluor's board of directors.

Ellsworth

Ellsworth's appointment brings the board to its total authorized membership of 11 directors. Ellsworth joined the Fluor sales staff in 1940, advancing to vice president of sales in 1952. Last year he became vice president and general manager, engineering and construction division. He is a graduate of Oklahoma A & M.

P. C. Spencer has been elected a director of Texas Pacific Coal and Oil Company of Fort Worth. Spencer is president of Sinclair Oil Corporation which recently acquired approximately 30 percent of Texas Pacific's stock.

Richard W. Kersey has been named chief process engineer of the Derby Refining Company, Wichita, Kansas. A Californian and 1944 graduate of the University of Southern California with a degree in chemical engineering, Kersey was chief process engineer for the Southwestern Engineering Company prior to joining the Derby organization.

Deaths

Dr. Camille E. Dreyfus, chairman of Celanese Corporation of America, died in New York City on September 27. He was the founder of his company and president from 1918 to 1945 when he became chairman. He was also president of Canadian Celanese Ltd., and managing director of British Celanese Ltd.

Rex E. Cheek, petroleum engineer with Ball Associates located in the firm's Washington headquarters, died in Georgetown Hospital, D. C., of a kidney ailment. He was 35 years old. Cheek was a graduate of Colorado School of Mines and the University of Oklahoma. He was a field engineer for Stanolind Oil and Gas Company before joining Ball Associates in 1953.

Eugene T. Singer, former vice president and director of Standard-Vacuum Oil Company, died in St. Petersburg, Florida, at the age of 69. Singer began his career in 1912 and served many Far East posts for Stanvac. He played a leading part in the company's post World War II refinery rehabilitation in the orient.

Photo courtesy Standard Oil Co., (N. J.)

stay on stream longer with the *LJUNGSTROM® AIR PREHEATER*

Slag—primary cause of reduced capacity—can be substantially reduced by the Ljungstrom Air Preheater...to keep you on stream *at top capacity* months longer.

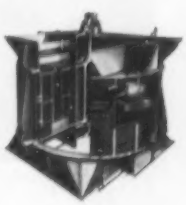
That's because preheated air mixes more thoroughly with fuel. The result is better combustion...and less slag-forming material present in the furnace. Oil tubes stay cleaner ...stills stay on stream at top capacity for months longer. As an example, one pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom and modern high-temperature burners, the still operates continuously at 18,000/20,000 barrels.

How fast is "WRITE OFF"?

By cutting turnaround time alone, the Ljungstrom means major savings for you. When you take the other Ljungstrom advantages into account—up to 20% fuel saving...more economical furnace design, with no need for convection surfaces...burns many fuels you used to throw away...consistently higher through-put...higher product quality—you can see why a Ljungstrom is paid out in just a few months.

For more complete details on what the Ljungstrom Air Preheater can do for you...for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

What Suppliers Are Doing . . .

Kappele

J. A. (Jerry) Kappele, formerly with Humble Oil & Refining Company, has joined his father's firm, **Kappele Engineering Company**, and will head the company's Tulsa office. Kappele Engineering Company is the manufacturers agent in Oklahoma and part of Kansas and Arkansas for Leslie Company reducing valves, Nicholson steam traps and Marshalltown gauges. M. T. Kappele, president, will continue to manage the firm and reside in Ponca City.

Kappele, a member of ASME, received his mechanical engineering degree from Oklahoma A. & M. in 1948 and was with Humble eight years in the maintenance engineering department at the company's Baytown refinery.

Hanssen

Albert J. Hanssen has been appointed chief engineer, **Conoflow Corporation**, Philadelphia. Hanssen possesses a wide background of engineering experience particularly suiting him for his new position. Before joining Conoflow, he was chief engineer of the Climax Division, Black, Sivalls & Bryson, Inc., manufacturer of control valves and regulators located in Tulsa, Oklahoma. Previously he was chief engineer for the McAlear Manufacturing Company, Chicago, and earlier, served with the War Department as construction engineer for a chemical processing installation near Savannah, Georgia.

As chief engineer, Mr. Hanssen's duties include supervision of the administrative and design functions of the engineering department.

Friedel

Howard H. Friedel was recently appointed sales engineer to the Process Equipment Division, U. S. Stoneware Co., Akron, Ohio. After receiving his B.S. in chemical engineering from Case Institute of Technology in 1940 he entered into research and development of organic chemicals for Hooker Electrochemical Co. at Niagara Falls, N. Y. During World War II he worked on the government magnesium program at the Painesville, Ohio, plant of Diamond Alkali.

Since the war Friedel has been in the sales field specializing in chemical processing equipment for the chemical and metal finishing industries. He is a registered professional engineer in Ohio and is a member of AIChE and NACE.

Flori

Robert D. Flori has been elected president of the new combination of the **Flori Pipe Company** of St. Louis and **The Houston Pipe & Steel Company** of Houston. This announcement was made by Mr. John J. Smith, president, the Sparks Withington Company, Jackson, Michigan, parent company of the new combination. The two companies will constitute the pipe fabricating operation of Sparks Withington following purchase by the latter company of 100% of the stock of Houston Pipe & Steel. The Flori Pipe Company has been a subsidiary of Sparks Withington since last February.

Cooley

Dr. Robert A. Cooley, formerly with Olin Mathieson Chemical Corporation, announced the incorporation of a new company, the **Propellex Chemical Corporation** in Edwardsville, Illinois.

The new company will conduct research and development on and manufacture of propellants and explosives. Major emphasis for the petroleum and mining field will be placed on gas generating devices such as oil well perforators, cement extruders, bridging plugs, and non-electric powered safety devices. These propellant powered tools include guided transport missiles, auxiliary gas generators for emergency power, ejection devices, and jet engine starters. More versatile and less expensive propellants based on fertilizer grade ammonium nitrate are rapidly being developed.

Hill

Ernest J. Hill has been appointed sales manager of **Colton Chemical Co.**, Cleveland, Ohio, a division of Air Reduction Company, Inc.

Hill, formerly assistant sales manager, graduated from the University of Cincinnati with a degree in chemical engineering. He spent the next twelve years in product sales to the paint, plastic, chemical, rubber and adhesive industries and was for five years in the Army Ordnance Department with rank of major. He has also held managerial sales positions with Ferro Chemical Co., Cleveland, and the Chemical Division of Goodyear Tire and Rubber Co. In his new capacity, E. J. Hill will be in charge of sales representatives and agents for Colton Chemical Co.

Clarke

Bruce T. Clarke, The Pfaudler Co., Rochester, New York, has been assigned to the Manhattan New York sales territory with offices in Hoboken, New Jersey.

Clarke, a mechanical engineering graduate of Case Institute, will handle the sale of Pfaudler's line of glassed steel and alloy processing equipment for the dairy, food, chemical and brewery industries in that area. He had had eleven years of sales and engineering experience before joining the Pfaudler Co.

Greene

Richard Greene has been named a representative for the **Warner Electric Brake & Clutch Company**, Beloit, Wisconsin, it was announced by Norman K. Anderson, vice president of the firm. Greene will make his headquarters at 7 Armat Court, St. Louis, Missouri.

Prior to joining the Warner organization, Greene had been associated with the Lincoln Engineering Company, St. Louis, and Aeroil Products Company, South Hackensack, New Jersey.

Hammond

Millard A. Hammond has been named manager of Welding Fittings Sales of **The Babcock & Wilcox Company**, Tubular Products Division.

Formerly in charge of fittings sales in the division's Philadelphia district, Hammond will be responsible for sales of the product through the 15 district sales offices throughout the U. S. and four foreign sales representatives of the division. His headquarters will be at the division's Milwaukee plant.

Chisholm

Charles G. Chisholm has been appointed general sales manager of **Haynes Stellite Company**, a Division of Union Carbide and Carbon Corporation. Chisholm joined Haynes Stellite Company in 1933 as a chemical laboratory assistant, and later was employed in various manufacturing departments. In 1936 he joined the General Sales department and was assigned to developing the sales of corrosion-resistant alloys. He later undertook the additional job of co-ordinating the sales of high-

Danger... Corrosion at work!

ABOUT THIS PHOTOGRAPH—In capturing this closeup of corroded "coupons" and a distance shot of a refinery on the same negative, well-known photographer Bernard Hoffman achieved amazing depth of focus. Using revolutionary techniques which he has pioneered, Mr. Hoffman is able to achieve over-all sharpness of near and far objects; long the goal of photographers.

Internal refinery corrosion, as measured by these badly corroded coupons, is becoming a thing of the past where Polyrad inhibitor is used. Because Polyrad is a filming amine, it forms a molecular film that protects metal from attack. And Polyrad's detergent action aids in keeping the metal surfaces clean, thereby maintaining heat transfer and operation at unit capacity.

Polyrad is available from stocks maintained throughout the country. We'll be glad to tell you how to protect your refinery with Polyrad.

POLYRAD®

FILMING AMINE INHIBITOR

Pine Chemicals Division, Naval Stores Department **HERCULES POWDER COMPANY** *976 Market St., Wilmington 99, Del.*

NA56-6

For more data on advertised products, use Readers' Service Cards, last page.

Transcontinental pipelines are among the many places where Cathodic Protection and Anaconda Type CP Cable are used to check corrosion.

Cable that helps make the pipeline a good neighbor

To make cathodic protection systems more economical and effective – to help pipeline and oil companies check costly corrosion, stop leaks, make pipelines good neighbors – Anaconda offers a special Type CP Cable that *lasts far longer* on the job than ordinary cable.

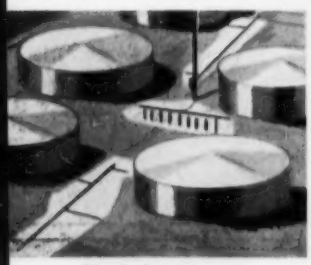
High-grade polyethylene insulation and tough Densheath* (PVC) jacket offer high resistance to electroendosmosis†, as well as high resistance to oil, moisture, and most acids, alkalies and chemicals found in corrosive areas. And rugged Densheath withstands toughest abrasion, moisture, sunlight and weathering.

For special applications, a one-layer insulation and jacket construction of polyethylene is available.

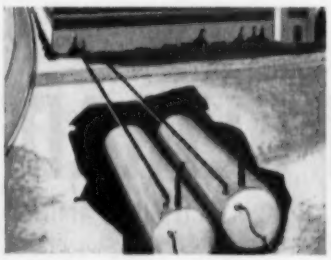
To order, or for more information—call the Man from Anaconda. Or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

*Reg. U.S. Pat. Office †Cable failure on direct current in wet locations 56357 Rev.

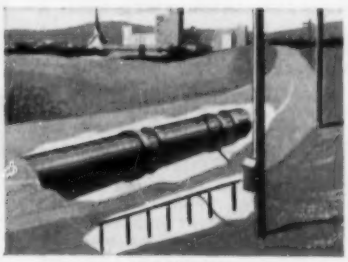
WHERE ANACONDA TYPE CP CABLE AND CATHODIC PROTECTION CUT CORROSION COSTS



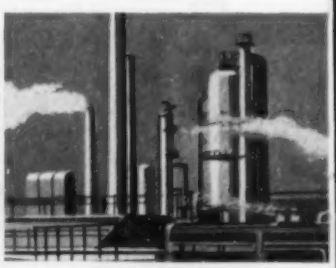
Tank farms



Underground storage tanks



Pipelines



Oil refineries

ASK THE MAN FROM ANACONDA
FOR CATHODIC PROTECTION CABLE

Suppliers . . .

temperature alloys. For the past several years he has been Sales Development Manager for investment-castings, as well as for high - temperature and corrosion - resistant alloys. Chisholm is a member of the National Association of Corrosion Engineers, the American Rocket Society, and the American Chemical Society.

Daniel Orifice Fitting Company recently announced the election of **W. A. Griffin** to the office of president.

He joined Daniel in Los Angeles in 1940, and has been vice president and general sales manager since late 1950. In his new post he succeeds **J. G. Holdenried** who will become executive consultant. With the appointment of Griffin, Daniel Orifice has embarked on an extensive expansion and development program. This program will include an expansion of the Houston plant facilities and a transfer of executive offices from Los Angeles to Houston. He has been active on several measurement research committees of the American Gas Association as a member of the gas measurement committee. In addition, Griffin is a member of the General Committee of the Southwestern Gas Measurement Short Course held each year at the University of Oklahoma.

Falstrom Company, Passaic, N. J., has installed a power press with a capacity of 260 tons, 10 inch stroke, and a 4 x 5 foot bed area. This new addition now enables Falstrom to introduce an advanced technique in metal fabrication. The equipment permits one piece blanking, drawing, forming, and embossing, where, heretofore, costly and complicated weldments were required. Closer tolerances are possible since welding distortion is greatly eliminated. In their die racks Falstrom carries over 2000 stock dies for blanking out cutouts used by the electronic industry.

Greer Hydraulics, Inc., has appointed **Archie N. Colby** general sales manager. Colby formerly was a senior associate with the management consulting firm, Bruce Payne & Associates of Westport, Conn.

Prior to his work in management consulting, Mr. Colby was with the Johns Hopkins University operations research office in Chevy Chase, Maryland, where he was an operations analyst and section chief in the Combat Operations Research Group.

Tube Turns Plastics, Inc. has added to its staff **Milo Harrison Buzzee,** industrial designer and research engineer who will direct the marketing of custom molded products and handle special assignments.

Buzzee was born in Easthampton, Mass., and obtained his B.S. degree in electrical engineering at Northeastern University. Throughout his career he has specialized in the development, manufacturing and marketing of plastic products.

Walworth Company, a leading manufacturer of valves and fittings, has acquired all the capital stock of **Grove Valve and Regulator Company** and **Grove Controls, Inc.,** both of Oakland, California. Walworth issued 208,500 shares of its common stock in the purchase. The Grove companies design and develop controls

2 Safe Ways to PROTECT Pressure Piping . . .

W-S SCREW-END and SOCKET-WELDING FORGED STEEL FITTINGS

Pipe joints are potential trouble spots in high pressure piping systems. Change in direction of flow causes turbulence, erosion and vibration. Watson-Stillman fittings are made to absorb this type of punishment. They're drop-forged for strength and toughness and safety-factor designed for the protection of your piping.

Choose between a welded piping system and a screwed one to suit your needs. Then choose W-S Screw-End or Socket-Welding Fittings to join your pipe. They're available in sizes ⅛" to 4" for piping up to 6000 lb. W.O.G. class. For high temperature or corrosive service you can get W-S Forged Stainless and Alloy Steel Fittings, too. Send today for our informative catalogs.

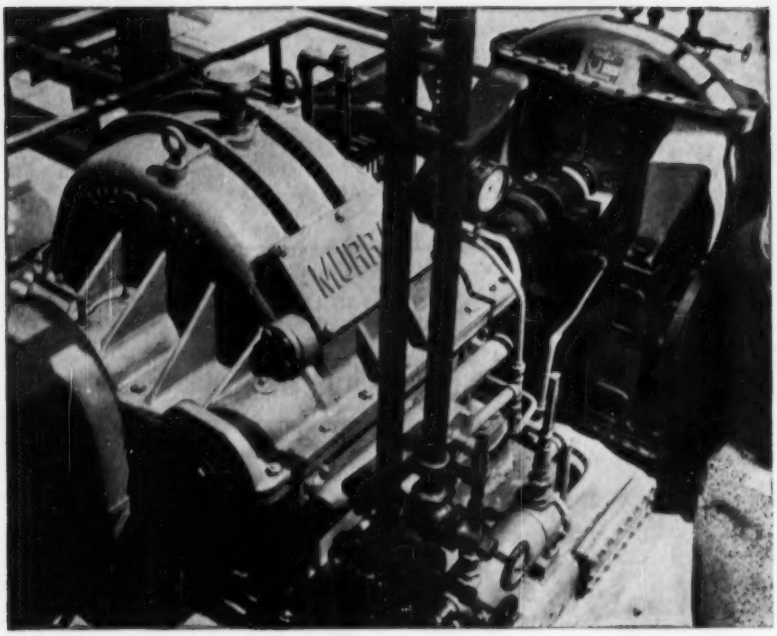
W-S FITTINGS DIVISION

HKP H. K. PORTER COMPANY, INC.

Roselle, New Jersey

For more data on advertised products, use Readers' Service Cards, last page.

Murray Turbines



One of 4 Murray type U turbo-gear units installed in a southwest rubber plant still giving trouble free service after 12 years in an unprotected outdoor location. This unit drives an Induced Draft Fan requiring 425 HP at 683 RPM. The turbine speed is 3500 RPM.

● Murray turbo-gear units for mechanical drive are right at home in difficult outdoor installations. Fans, pumps, compressors, and many special types of slow speed machines are among the long list of installations powered by Murray turbo-gear units.

Murray gears are of the Herringbone or Double Helical type and all are pressure lubricated at the point of tooth contact.

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

Suppliers . . .

and high pressure regulators for the oil, gas and chemical industries. In recent years Grove has developed giant fabricated steel gate valves for natural gas and oil transmission lines.

In addition to the Grove plant in Oakland, Walworth will take over a recently-constructed plant in Longview, Texas.

Worthington Corporation has named **F. Kenneth Morrison** president and general manager of its Mason-Neilan Division. Morrison succeeds **Eldon Macleod**, who is retiring after forty-three years.

Starting with the Mason Regulator Company in 1924 as a salesman, Morrison was promoted to general sales manager in 1927 and continued in that capacity after the merger with the Neilan Company in 1931. In 1933 he was elected vice president in charge of sales.

General Controls Company, manufacturer in the automatic controls field, announces new facilities in the St. Louis Branch territory. The new General Controls building affords larger warehouse facilities for servicing its customers with its line of residential, industrial and aircraft controls.

The C. H. Grant Company, Oakland, California, has been appointed manufacturer's representative for the sale of Cleaver-Brooks asphalt heating and pile driving equipment.

The C. H. Grant Company assists in the setting up of complete asphalt heating plants. The company's territory is located in 45 counties in the vicinity of San Francisco.

Leeds and Northrup Company, manufacturer of automatic control systems, electrical measuring instruments, and heat-treater furnaces, has moved into its new, ultra-modern plant in North Wales in the suburban Philadelphia area. The brick, steel, glass and ceramic tile structure, covering nearly six acres, is not quite so large as the company's main plant in Philadelphia. Over 1300 employees, many of them transferred from other locations, manned the new plant initially. The installation includes facilities for plastics production, tool making, heat treating, milling, drill and punch presses, casting machining, and electronic recorders.

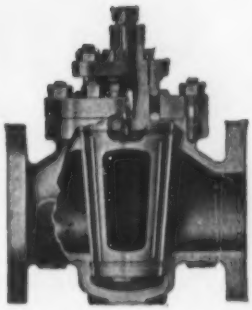
The North Wales plant was designed by Giffels and Vallet Inc., L. Rossetti, Detroit engineering and architectural firm. Baton Construction Company was the builder. Total cost of land, buildings, inventory, and equipment was about $11 million.

Chapman Chemical Company announces the appointment of **L. R. Harshman** to a new post in its home office at Memphis to develop technical service and sales policies exclusively for the rapidly expanding fields involving the use of organic insecticides outside of agricultural uses.

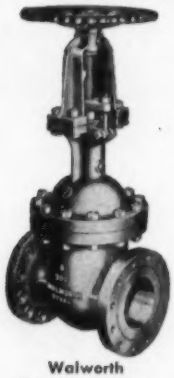
Harshman, a graduate of the University of Michigan, has been Chapman's sales representative in Alabama for the past five years. Replacing him in Alabama is **Richard M. Bridgman,** who holds both B.S. and M.S. degrees in agricultural science from Alabama Polytechnic Institute at Auburn. Mr. Bridgman was for-

● VALVES

● PIPE FITTINGS



Walworth
Lubricated Plug Valve



Walworth
Steel Gate Valve

Walworth
Iron Body Gate Valve

Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

Walworth
Cast Steel Flanged Fittings

Walworth manufactures a *complete line* of valves and pipe fittings: all made to the highest standards of quality, both as to dimensional accuracy and metallurgical properties. In design, construction, and performance, Walworth products reflect more than a century of experience in the manufacture of quality valves and fittings.

Your Walworth distributor will give you full information on the *complete line* of Walworth steel, iron, and bronze, and special alloy valves and pipe fittings; also Walworth Lubricated Plug Valves, and Walseal* valves, fittings and flanges. Ask for this information today.

*Patented—Reg. U. S. Pat. Off.

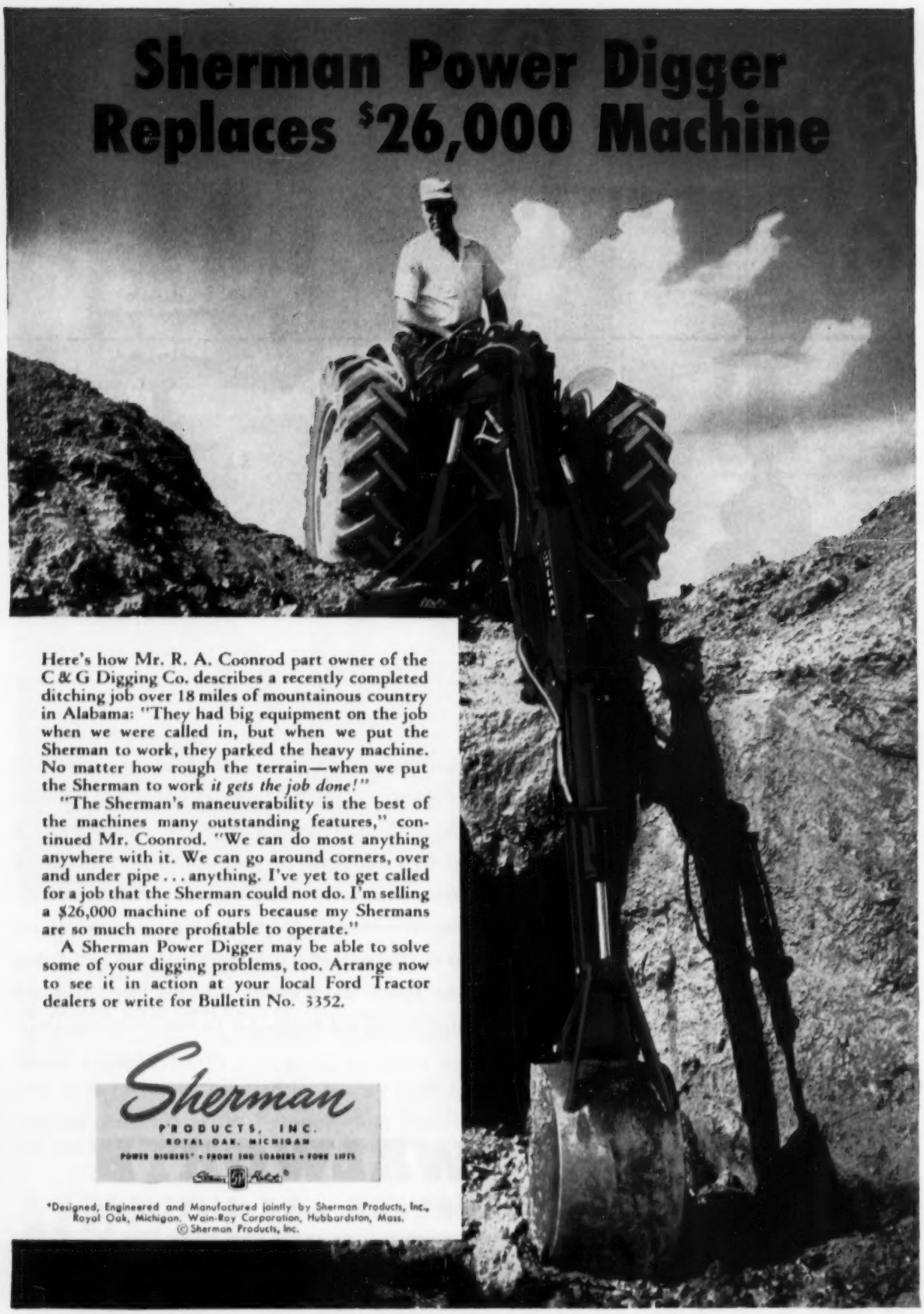
WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

Sherman Power Digger Replaces $26,000 Machine



Here's how Mr. R. A. Coonrod part owner of the C & G Digging Co. describes a recently completed ditching job over 18 miles of mountainous country in Alabama: "They had big equipment on the job when we were called in, but when we put the Sherman to work, they parked the heavy machine. No matter how rough the terrain—when we put the Sherman to work *it gets the job done!*"

"The Sherman's maneuverability is the best of the machines many outstanding features," continued Mr. Coonrod. "We can do most anything anywhere with it. We can go around corners, over and under pipe . . . anything. I've yet to get called for a job that the Sherman could not do. I'm selling a $26,000 machine of ours because my Shermans are so much more profitable to operate."

A Sherman Power Digger may be able to solve some of your digging problems, too. Arrange now to see it in action at your local Ford Tractor dealers or write for Bulletin No. 3352.

Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
POWER DIGGERS* • FRONT END LOADERS • FORK LIFTS

*Designed, Engineered and Manufactured jointly by Sherman Products, Inc., Royal Oak, Michigan, Wain-Roy Corporation, Hubbardston, Mass.
© Sherman Products, Inc.

Suppliers . . .

merly with The Progressive Farmer magazine in Chicago and served for four years as a special agent with the F.B.I.

Murl D. Nance, formerly of Waco, Texas, was appointed sales representative at Columbus, Ohio. Formerly with Pfizer Pharmaceutical Laboratories, Nance is a graduate of the University of Tulsa.

The Cardinal Carryor Company of Louisville has been named franchise representative for the sale and service of industrial lift trucks by **The Yale & Towne Manufacturing Company.**

The company, headed by its founder **C. C. Brumleve,** has 10 years experience in the sales and service of materials handling equipment to Kentucky industry.

Ethyl Corporation has created a Product Service and Safety department to replace the former Safety department. **Henry K. Ball,** who has been manager of Safety, will continue as manager of the new Product Service and Safety department. Ball, who has been associated with Ethyl for 25 years, has had extensive experience in the handling of "Ethyl" fluid in the field.

As part of Ethyl's continuing program of safety education, four motion pictures on the handling of "Ethyl" antiknock compound and leaded gasoline are now available from its Product Service and Safety department.

Frick Company, Waynesboro, Pa., has moved its Branch Office in Philadelphia from the Witherspoon Building to 408 Wilford Building, Thirty-third and Arch Streets. **Cyril Leech** is branch manager.

Metal Goods Corporation's Memphis district office and warehouse, has announced the appointment of **Hugh J. Madigan** as the company's sales representative in central and eastern Tennessee.

Madigan joined Metal Goods Corporation as a sales trainee in September, 1948, at the company's Dallas, Texas, plant. After completion of his training course, he was assigned to the inside-desk sales department. From this position he was assigned to the outside sales force in the Dallas area.

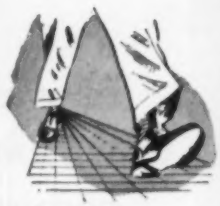
Norton Company has appointed **William F. Watts** factory superintendent of the recently formed refractories division. Watts will be responsible for the manufacture of refractories, hot rod heating elements, Norbide boron carbide, and special products made by the division.

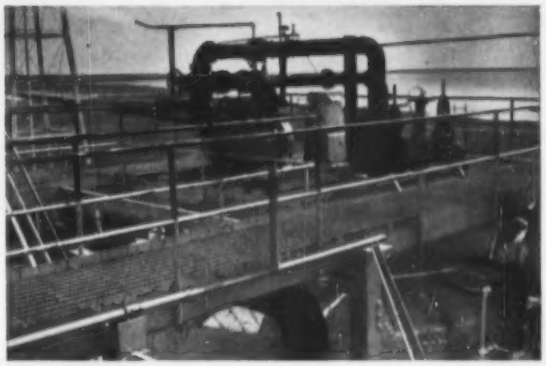
William P. Densmore has been appointed chief industrial engineer of the refractories division of Norton Company. A graduate of Worcester Polytechnic Institute, he joined the company ten years ago as a time study engineer. In 1953, he was appointed assistant chief industrial engineer, a post he held until his present appointment.

Nordberg Manufacturing Company has appointed **Diesel Engine & Equipment Service Company** as distributor of Power Chief Diesel engines in 19 counties in southeastern Texas. Sales and service facilities of the company are located in Houston.

Ralph Austin is president and general manager of the firm which was organized

WHERE **SURE FOOTEDNESS** COUNTS





Gary

STEEL GRATING MAKES WALKS SAFER

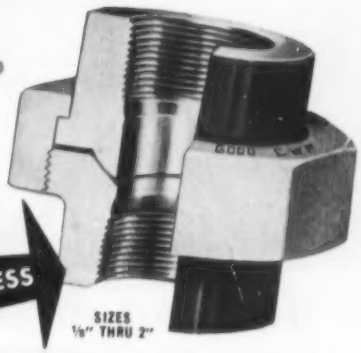
Sturdy, one-piece construction with tops of all bars flush provides open steel flooring and stairs for safe, easier walking. Gary Grating is furnished in a wide variety of neat appearing designs and sizes—and is tailor-made to fit your needs. For complete description and installation pictures on Gary Welded Grating, Stair Treads and Gary-Irving Decking, ask for Catalog PR-116.

FREE SAMPLE
We'll send this handy paper weight if you request it on your company stationery.

Standard Steel Spring Division
ROCKWELL SPRING AND AXLE CO.
4011 East Seventh Avenue • Gary, Indiana

NEW petro
6000 LBS.
C.W.P.

FORGED STEEL UNIONS
Ideal for High Pressures of Gases or Liquids, Hot Oils, High Temperatures, Ammonia Hot or Cold & Power Piping



HEAVIER WALL THICKNESS

SIZES
⅛" THRU 2"

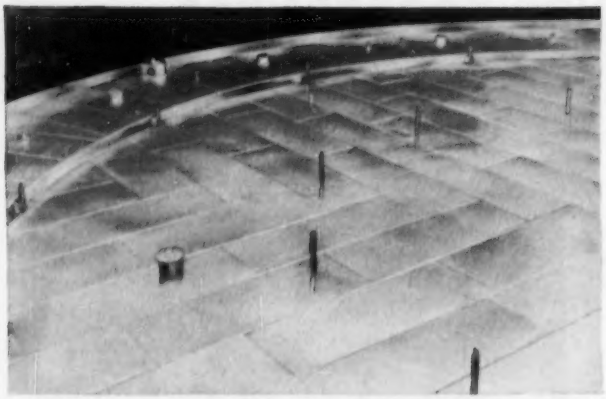
- The wall thickness of this New Petro Union has been greatly increased to easily withstand the severe demands of higher pressures and hot or cold temperatures. It is drop forged from uniformly heated steel forging bars. Grain and fibre structure are refined through the controlled hammer impact on the hot, plastic metal as it is confined in the closed dies. The hot forging develops the tensile and torsional strength, the toughness and fatigue endurance required to enable the finished Union to resist the most complex stresses and strains ever present in high pressure and high temperature piping systems.
- Nuts are octagon in shape and are Udylited. The nut threads are rust-proof, spark-proof and permanently lubricated with Udylite Cadmium.
- The ends are also octagon in shape to provide flat gripping areas for wrenches.
- The ends are tapped, sharp and clean, per American Standard B 2-1 1945 (for tapered pipe threads).

THE "ECONOMY PLUS" UNION

You'll get greater ruggedness, dependability and service with a minimum of downtime or maintenance time. Considering the original low cost it's the most economical Union you will ever buy.

MAIL THIS COUPON TODAY!
PLEASE SEND US COMPLETE INFORMATION ON THE 6000 LB. PETRO
NAME _____
ADDRESS _____ CITY _____ ZONE _____ STATE _____
CLAYTON MARK & COMPANY • 1900 Dempster Street • Evanston, Illinois

For more data on advertised products, use Readers' Service Cards, last page.



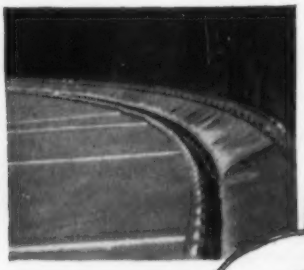
New Jersey—140′ x 40′—110,000 bbl. capacity

California—160′ x 40′—140,000 bbl. capacity

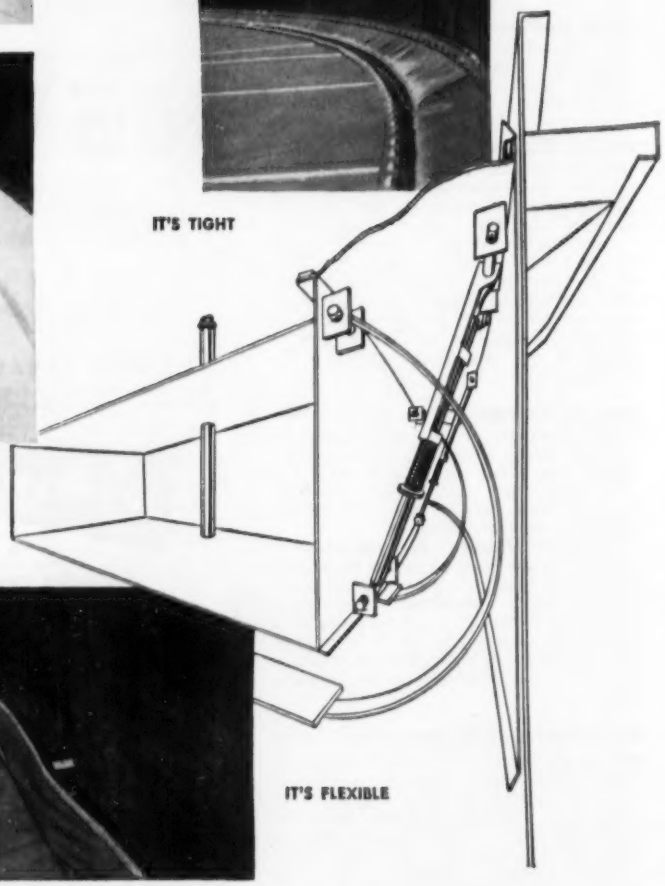
Texas—90′ x 48′—55,000 bbl. capacity

PROVED WHERE ECONOMY COUNTS...

The demands for more production and greater storage capacity with the least investment has attracted a number of well-known companies to the new low-cost Graver under-deck center-weighted floating roof tank. The typical installations at the left show the obvious advantages of Graver's new clear-deck single roof in all climates.



IT'S TIGHT



GRAVER®

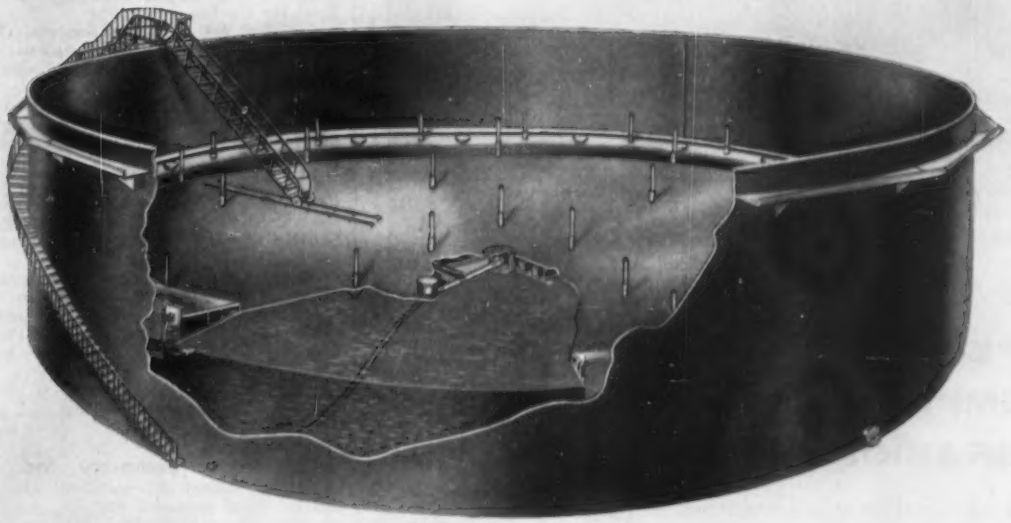
SINGLE VAPOR-STOP SEAL

Graver's patented Vapor-Stop single seal is an inherent feature. This effective seal rides "tight" over weld seams on new construction and rivets on re-roofed tanks.

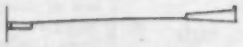
IT'S FLEXIBLE

GRAVER

WE'VE CLEARED THE DECK...

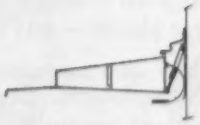


STABLE . . . because, ship-like, the center of buoyancy is below the center of gravity.



CORROSION-RESISTANT . . . because the liquid in storage is in full contact with the deck.

SELF-DRAINING . . . rainfall flows to the Graver sump at the center low point of the roof.



VAPOR-STOP SEAL . . . Graver's patented single seal . . . proved effective against vapor loss.

. . . FOR A NEW, LOW-COST FLOATING ROOF TANK WITH UNDER-DECK CENTER WEIGHT

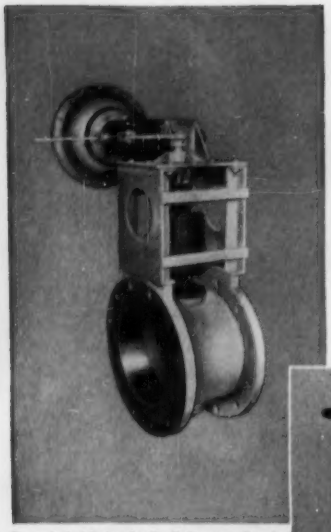
Here is another outstanding Graver first in single-deck floating roof tanks. We've cleared the deck for easy snow removal and positive drainage by putting the center weight *below* the deck. This effects additional economies in construction without sacrificing the long-established advantages of Graver's patented single-deck floating roof principle and characteristic Graver quality. This new Graver floating roof tank (both pontoon and pan type) has been thoroughly proved by installations across the nation. May we give you complete details?

GRAVER

GRAVER TANK & MFG. CO., INC.

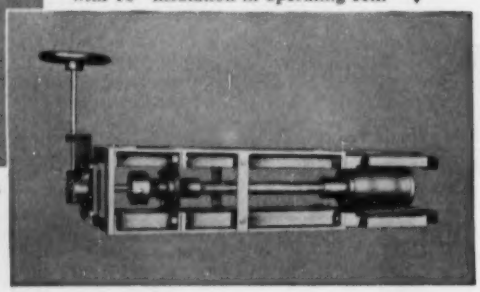
EAST CHICAGO, INDIANA • NEW YORK • PHILADELPHIA • EDGE MOOR, DELAWARE
PITTSBURGH • DETROIT • CHICAGO • TULSA • SANDS SPRINGS, OKLAHOMA
HOUSTON • LOS ANGELES • FONTANA, CALIFORNIA • SAN FRANCISCO

For more data on advertised products, use Readers' Service Cards, last page.



R-S BUTTERFLY VALVES

All-bronze, 150-pound R-S Valve for operation at −300° F. Valve is installed with 18″ insulation in operating cell. ▼



Special 12-inch R-S Butterfly ▲ Valve, with finned lubricated stuffing box, is used for service with hot gases at 1,000° F.

SPECIAL R-S VALVES SOLVE TEMPERATURE, CORROSION, ABRASION PROBLEMS

To meet rugged processing conditions, R-S Butterfly Valves can be built to your requirements. For valve bodies and parts, any metal or other material that can be cast or welded — even plastics — may be specified.

There are a number of materials available to meet extreme working conditions involving corrosion, abrasion, erosion, high heat and pressure. In addition, the R-S Rubber-lined Valve may be specified to resist certain types of corrosion. Every R-S Valve gives you quick and positive closure with any type of controls, uniform control in normal regulating ranges and minimum pressure drop.

If your past experience offers no precedent, you can call on our background in specialized valve engineering to solve material problems.

We have built valves to operate in a temperature range of from −300° F to +2,000° F. For complete information on our complete line of butterfly, ball and cone valves, see our local representative or write S. Morgan Smith Company, York, Pennsylvania.

HYDRAULIC TURBINES · GATES & HOISTS · TRASH RAKES · PUMPS · ACCESSORIES

HYDRODYNAMICS

ROTOVALVES · FREE-DISCHARGE VALVES · BALL VALVES · CONTROLLABLE-PITCH SHIP PROPELLERS · BUTTERFLY VALVES

S. MORGAN SMITH

AFFILIATE: S. MORGAN SMITH. CANADA, LIMITED • TORONTO

Suppliers . . .

in March, 1954. **Cecil Brown** is vice president and shop manager and **Joe Pena** is parts manager. The company has 11 mechanics and field personnel.

Orbit Valve Company held a three-day sales meeting for regional and district managers in October, with all main sessions conducted in conference rooms at the Tulsa Club.

Orbit's key field men throughout the United States met with the Tulsa valve manufacturer's top executives for an important three-day conference reviewing company progress and hearing plans outlined for the future.

President **Ed D. Ligon** reviewed Orbit Valve's past few years growth, and detailed plans for growth and expansion during the next five to ten years.

The meeting's consensus was that oil country valve sales will continue strong for the remainder of this year and throughout 1957.

Pfaudler Co. of Rochester, New York, announced the assignment of **Anthony P. Sullivan** to the field sales territory including North and South Carolina.

An industrial engineering graduate of Oklahoma A & M College, Sullivan will be located in Charlotte, North Carolina, as sales engineer handling the sale of Pfaudler's line of glassed steel and alloy processing equipment.

His background includes experience in personnel, industrial engineering and commercial sales engineering.

H. K. Porter Company, Inc., has appointed **Robert N. Smaistrla** Houston district sales manager for the Lacelede-Christy Company Division. His territory includes southern sections of Texas and Louisiana.

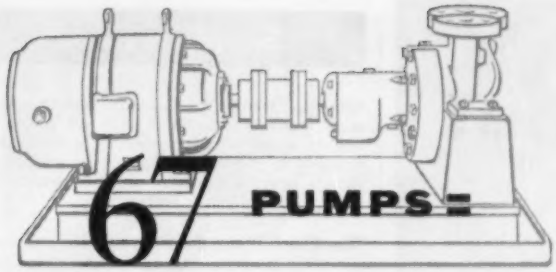
Smaistrla is active in the Petroleum Branch of the American Institute of Mining and Metallurgical Engineers and is a member of their membership committee. He is an active member of the American Petroleum Institute, a member of the American Society of Mechanical Engineers, and a registered professional engineer in Texas.

Adsco Industries, Inc., has named **Richard G. Lyall,** who has been serving as chief engineer, as vice president in charge of engineering. A graduate of Cornell University with a degree of civil engineering, Lyall worked for the Lackawanna Steel Construction Company from 1930 to 1936, when he became associated with Farrar & Trefts, Inc., and later was vice president in charge of engineering. Farrar & Trefts is now a division of Adsco Industries, Inc.

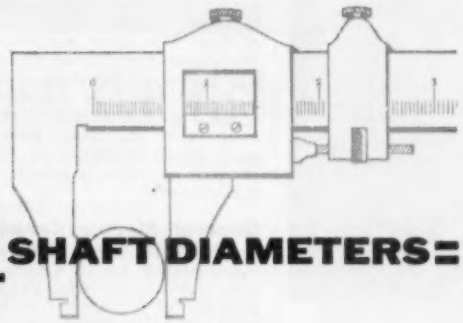
Humphreys & Glasgow (Canada) Ltd. has been incorporated as an associate company of **Humphreys & Glasgow Ltd.,** of Humglas House, Carlisle Place, London, S. W. 1.

The address of the new company is 837 Eglinton Avenue West, Toronto 10, Ontario, and its activities entail engineering and plant construction for the gas, petroleum, chemical and other process industries.

Apart from the board of directors, the principal executives of the new company are **Peter de Gray,** vice-president sales, and **C. T. Hawkes,** vice-president engineering.

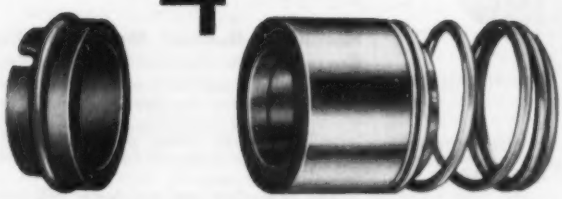


67 PUMPS=



14 SHAFT DIAMETERS=

4 SEALS



SEALOL FLEXIBOX BALANCED SEALS REDUCE INVENTORIES

4 TO 1!!

- A recent refinery survey revealed that 67 pumps involving 14 shaft diameters required only four sizes of SEALOL Flexibox Balanced Pressure Seals.

THIS MEANS:

Fewer parts for 100% protection.
Maintenance and stocking procedures simplified by minimum parts handling.

- SEALOL Flexibox Balanced Seals come in only twenty-one standard sizes to fit all shafts with diameters from ¾" to 4¼". Teflon ® or O ring equipped seal components are dimensionally interchangeable.
- Send for your SEALOL Sealector which will enable you to properly survey your own operation!!

SEALOL CORP.
185 POST ROAD, PROVIDENCE 5, R. I.

Baton Rouge • Chicago • Cleveland • Corpus Christi • Houston • Los Angeles • New Orleans • New York • Philadelphia • San Francisco • St. Louis • Toronto and Montreal, Canada • Flexibox Ltd., Manchester (Eng.) • Paris • Frankfurt

SEALOL

THE ▲ BALANCED PRESSURE SEAL

Not a Secret Vise!

Known Everywhere As Extra-handy and Rugged

RIDGID Bench Pipe Vise—8 sizes for ⅛" to 6" pipe

RIDGID

More-for-your-money pipe vises

Easy to Work With—LonGrip jaws for firmer pipe grip *plus* pipe rest for accurate threading and cutting. Built-in handy pipe bender—a time saver . . .

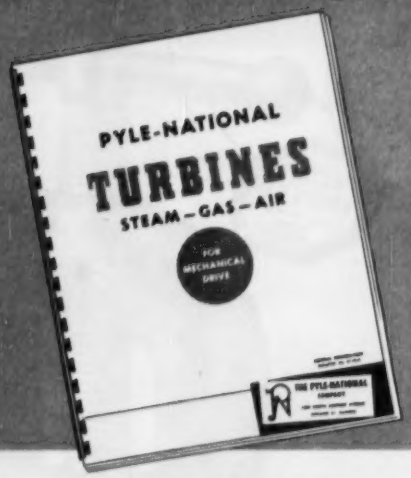
Years of Service—Replaceable long-life tool-steel jaws. Yoke and base of special tough malleable . . . Same quality in all RIDGID vises, yoke and chain. Order from your Supply House!

RIDGID
Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

Do you have a mechanical drive problem?



TURBINE SELECTION AND ENGINEERING DATA BOOK

The most complete reference available to answer your questions on turbines . . . at-a-glance information on speeds, B.H.P., pounds-steam/B.H.P.-hour at various steam pressures.

Request your copy today on your company letterhead.

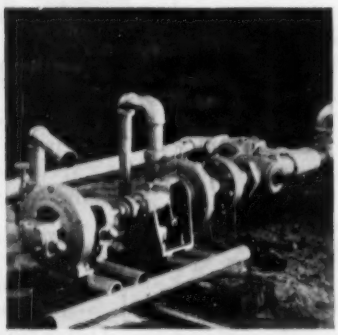
59 years' experience in turbine development

PYLE-NATIONAL TURBINES

¼ to 120 HP for mechanical drive

—the turbines that ask no favors in the refinery or in the field

- Weatherproof!
- Rugged!
- Trustworthy!
- Easiest of all turbines to service and maintain!



Also available: Turbo-Generators (½ to 15 KW)
Turbo-Alternators (60 cycle ½ to 20 KW)

SINCE 1897

THE PYLE-NATIONAL COMPANY
WHERE QUALITY IS TRADITIONAL
1393 N. Kostner Avenue, Chicago 51, Illinois

Branch Offices and Agents in Principal Cities of the U.S. and Canada • Canadian Agent: The Holden Co., Ltd., Montreal • Railroad Export Department: International Railway Supply Co., 30 Church St., New York 7, N.Y. • Industrial Export Department: Rocke International Corp., 13 E. 40th St., New York 16, N.Y.
CIRCUIT CONTROLS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS

Suppliers . . .

Norwood Works as assistant works manager, a position he held until his promotion to works manager there. He succeeds **Arnold I. Thorsen,** who was recently named general manager of Allis-Chalmers Terre Haute (Ind.) Works.

The Flori Pipe Company of St. Louis and **The Houston Pipe & Steel Company** of Houston now constitute the pipe fabricating operation of the **Sparks Withington Company,** Jackson, Mich. Parent company of Flori Pipe since last February, Sparks Withington has effected the unification by purchase of all the stock of Houston Pipe & Steel. This new combination will be under a unified administration with headquarters in St. Louis. **Robert D. Flori,** chief executive officer of Flori Pipe for the past six years, is president of the new organization.

General Electric Corporation has appointed **H. Dean Wolfe** as a district representative for its Construction Materials southwestern sales district. Wolfe, a graduate of the University of Pittsburgh with a B.S. degree in I.E., was with the Baltimore Gas & Electric Company prior to joining General Electric. In his new position, he will handle the division's wire and cable products in the New Orleans trading area.

Hamilton Rubber Manufacturing Corporation, Trenton, N. J., has announced the completion of new warehousing facilities for its South-Atlantic sales territory. This warehouse, located in Atlanta, Ga., will make possible one-day delivery of the company's rubber products in a six-state area.

The new office and warehouse will handle the sales and distribution of the company's complete line of industrial rubber products to distributors in Georgia, Alabama, Florida, South Carolina, North Carolina and Tennessee.

Jones & Laughlin Supply Division, Tulsa, Oklahoma, announced two recent changes in the firm's store operations.

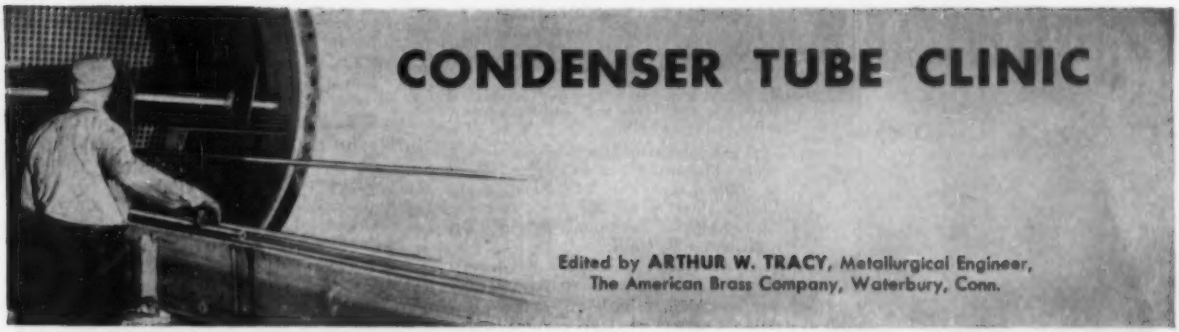
Jack A. Beaird, formerly at Sherman, Texas, has been transferred to Tulsa, Oklahoma, as local store manager of the central warehouse, and **T. P. Dellone** has been appointed to succeed Beaird as local store manager at Sherman.

Bohnert Equipment Company, Inc., Louisville, Ky., has been named distributor for the materials-handling trucks manufactured by the **Baker-Raulang Company,** Cleveland. Bohnert sales and service facilities will handle Baker's complete line of gas and electric fork, platform, and crane trucks, the Shoveloader front-end loader, and the Traveloader side-loading fork lift truck.

Beckman Instruments, Inc., has appointed **Byron E. Blakeman** as quality control consultant for the Helipot Division. Blakeman will organize a program designed to maintain product quality standards and production efficiency throughout Helipot's manufacturing processes.

Blakeman is the author of "Statistical Quality Control in Action." The book, a standard reference for training quality control supervisors, is used by the Armed

For more data on advertised products, use Readers' Service Cards, last page.



CONDENSER TUBE CLINIC

Edited by **ARTHUR W. TRACY**, Metallurgical Engineer,
The American Brass Company, Waterbury, Conn.

Choose the right alloy for your condenser tubes

LONG condenser tube life depends on the proper choice of alloy as well as conditions of operation.

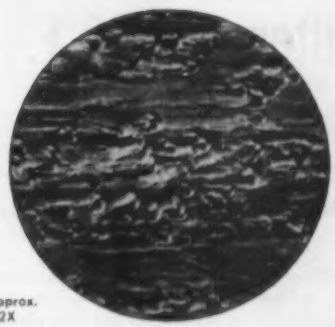
Fresh inland cooling water normally does not cause corrosion problems; either ANACONDA Arsenical Admiralty-439 or ANACONDA Phosphorized Arsenical Copper-108 tubes will give long service. ANACONDA Ambronze-421 tubes have been found more durable for river waters polluted with acid coal-mine drainage.

Sea water is usually more corrosive than fresh water. Clean sea water flowing turbulently, especially when air bubbles are present, causes inlet-end impingement pitting. Lowering the velocity, with subsequent smoother water flow, will solve this problem; but such a solution is not always economically feasible. ANACONDA Ambraloy-927 tubes are definitely more resistant to impingement corrosion than are admiralty metal tubes. Where water velocities are relatively high, ANACONDA Cupro Nickel, 10%-755 tubes can be expected to give even better service. ANACONDA Cupro Nickel, 30%-702 tubes are considered for the highest water velocities normally encountered in exhaust condensers.

Sea water in harbors and at river inlets is often polluted with decomposing organic matter which may settle in condenser tubes and cause deposit pitting. Hydrogen sulfide, a product of the decomposition, is also an important factor in corrosion by polluted waters because poorly protective scales containing metallic sulfides are formed. Chlorinating polluted waters is helpful in preventing deposit attack. Frequent removal of debris by brushing is an important factor in increasing tube life. Ambraloy-927 tubes generally give long service handling polluted sea water. In some cases, either Cupro Nickel, 10%-755 or Cupro Nickel, 30%-702 have served best because they are more resistant to deposit pitting.

Approx. 5.2X

DEPOSIT PITTING in uninhibited Admiralty Metal tube from a tidewater power station condenser. In this case a deposit of paper pulp is believed to have shielded a small area, forming an oxygen-concentration cell. The shielded area—low in oxygen content—is anodic and corrodes. Surrounding areas in contact with the solution high in oxygen form the cathode. Since the potential between the two areas is quite small, deposit pitting is usually a slow process.



Approx. 3.2X

IMPINGEMENT PITTING in an Admiralty Metal tube from the main condenser of an oil tanker. Excessively high water velocity caused turbulence, which carries away metal ions so that a protective film cannot form. An ion-concentration cell is formed, with the low-ion impinged area anodic; the areas where streamline, undisturbed flow persists, being cathodic. Air bubbles, water velocity, hydrostatic pressure drops in the tube, and alloy content, are all factors in this problem.

Some ANACONDA Condenser Tube alloys especially resistant to pitting, and their nominal compositions

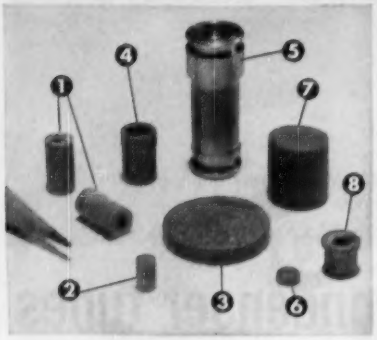
	Arsenical Admiralty -439	Ambraloy -927	Ambronze -421	Cupro Nickel, 10%-755	Cupro Nickel, 30%-702
Copper, %	71	77	88	88.35	68.90
Nickel, %	—	—	—	10	30
Zinc, %	27.96	20.96	10	—	—
Aluminum, %	—	2	—	—	—
Tin, %	1	—	2	—	—
Arsenic, %	0.04	0.04	—	—	—
Iron, %	—	—	—	1.25	0.50
Manganese, %	—	—	—	0.40	0.60

TECHNICAL ASSISTANCE—Your tube problem may require special consideration and analysis. We are always ready to help with such problems and advise in the selection of the right alloy to give the best service. Write for the new edition of our Publication B-2 on "Anaconda Tubes and Plates for Condensers and Heat Exchangers." The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6877

ANACONDA®
Tubes and Plates for Condensers and Heat Exchangers

For more data on advertised products, use Readers' Service Cards, last page.

FILTRATION NEWS



Filter to 900°F... anywhere!

PORO-KLEAN gives designer new freedom in filtering hot, hi-pressure fluids

"Versatile" is the word for Cuno's PORO-KLEAN filters when it comes to providing 3-30 micron filtration in hot spots and tight places!

In a tremendous variety of sizes and shapes, these new porous stainless steel filters are everywhere pushing back the temperature and pressure frontiers in micronic filtration. The reason: PORO-KLEAN'S unique combination of physical properties. Its high strength, exceptional heat and corrosion resistance and adaptability to a wide variety of shapes makes it easy to apply both in industrial processing and in compact aircraft and missile hydraulic systems.

For instance take the tiny preformed shapes shown above. They are: cylinder (1), cup (2) and cup with lip (4)—all used to protect micro-finished aircraft hydraulic servo valves; disc (3) for oil filter, cylinder (5) with brazed-on seat for hydraulic O-ring; disc (6) for gas-turbine fuel-oil nozzle; cup (7) and (8) for diesel fuel-oil nozzle.

And, for the big jobs, you can get single or multiple PORO-KLEAN units like the 54-inch element (below, right). It's designed to filter synthetic polymer in a chemical plant with 1500 psi pressure drop and operation at 550°F.

If you have a tough filter problem, get all the details on Cuno PORO-KLEAN. You can be sure it will fit into your design. Write: The Cuno Engineering Corporation, 34-11 South Vine Street, Meriden, Connecticut. 6-2

CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

Suppliers . . .

Forces and colleges and industries throughout the United States, Canada and Europe.

A consultant in the field for the past 10 years, Blakeman has established a number of statistical quality control programs for Pacific Coast firms. He recently completed a program for Beckman's Berkeley Division at Richmond, Calif.

H. K. Porter Company, Inc., has announced that its W-S Fittings Division's Atlanta sales territory is now organized. The territory was instituted earlier this year to take advantage of the promising potential of the southeastern U. S. The Atlanta office will serve seven states—Florida, Georgia, Mississippi, Alabama, South Carolina, North Carolina and Tennessee.

The Atlanta territory will be managed by **James M. Tough,** who has much experience in the sales end of the fittings business.

J. B. Rea Compnay, Inc., has appointed **Cecil R. Russell** as vice president. Russell, who joined the firm as project engineer in 1953, will now serve as vice president in charge of engineering and production. He came to the J. B. Rea Company from Logistics Research, Inc., where he was vice president in charge of engineering. Prior to that he was supervisor in charge of engineering and production of digital computers for Northrop Aircraft Inc.

Lloyd E. Schumacher, who has been with the company since 1953, and was previously vice president in charge of Engineering and Production, has been reassigned vice president in charge of Customer Relations.

Stauffer Chemical Company has appointed **F. J. De Santis** New York District Sales Manager of the Industrial Chemical Division.

De Santis is a graduate of the Massachusetts College of Pharmacy, and holds degrees in Pharmacy and Pharmaceutical Chemistry. Prior to joining Stauffer several years ago, he was associated for ten years with a major chemical producer as its New England representative.

Robert R. Dalrymple of Stauffer's New York Office, has been named Industrial sales representative for the New England area of the Stauffer Chemical Company to succeed De Santis. Dalrymple is a chemical engineering graduate of the University of Virginia. Prior to joining Stauffer he had several years' experience in process and sales engineering with the Hayden Chemical Corporation.

Schutte and Koerting Company, Cornwells Heights, Bucks County, Pa., has announced the appointment of **C. W. Alsentzer** as purchasing agent for the company.

A graduate of Northeast High School in Philadelphia, Pa., Alsentzer attended Drexel Institute of Technology before joining Schutte and Koerting Company in 1948 as assistant to the production manager.

Grover Tank & Mfg. Company, Inc., announced the advancement of **Henry J. D'Aragon** to general sales man-

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LIQUEFIED PETROLEUM GASES, REFRIGERANTS and other LIGHT NON-VISCOUS LIQUIDS
Bothersome to You?
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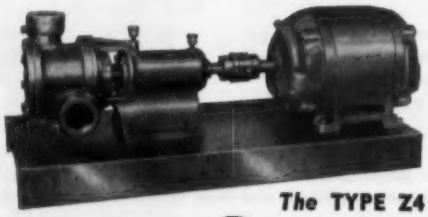

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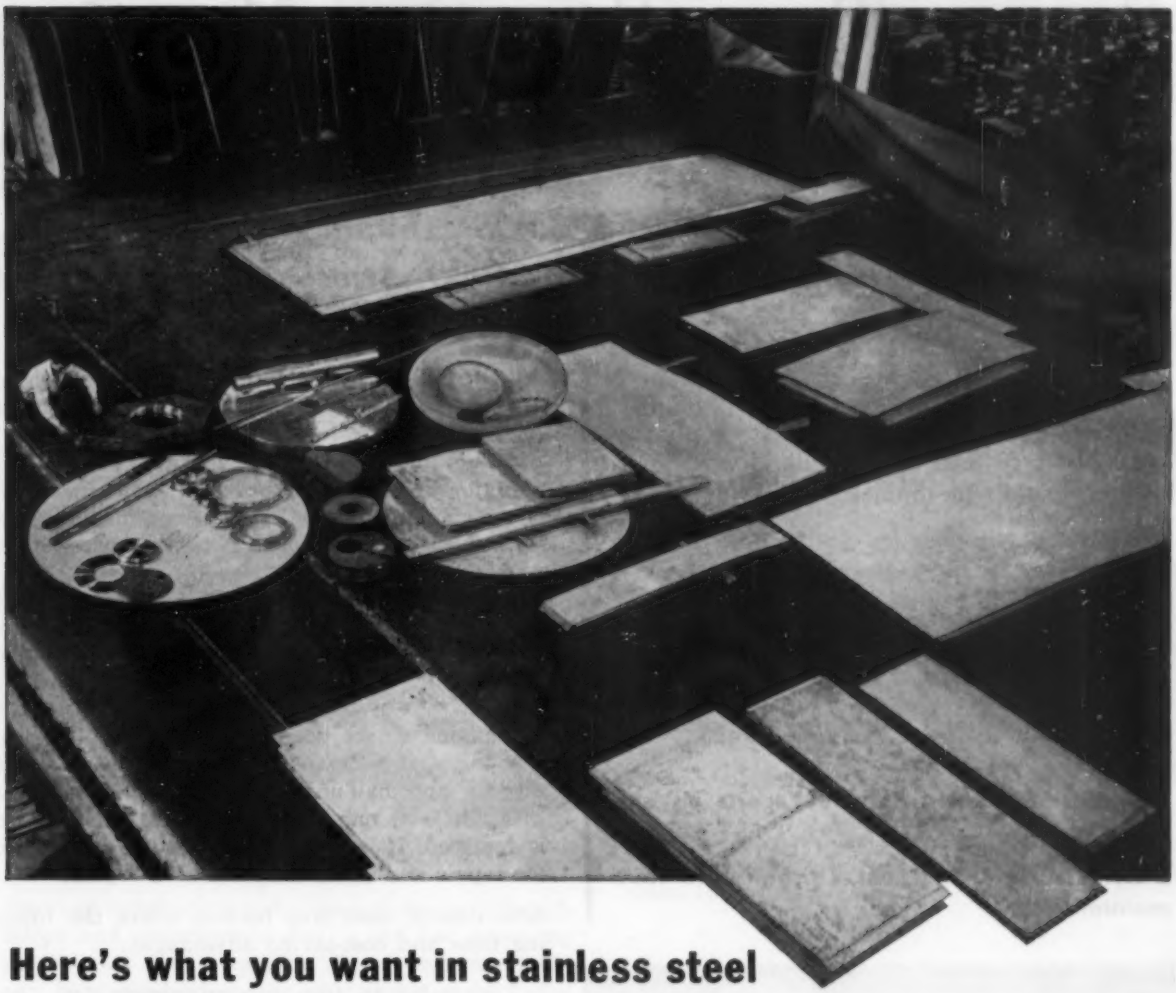

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For more data on advertised products, use Readers' Service Cards, last page.

Steam Trap Standardization Slashes Trapping Costs

Major User Reports $25,000 Annual Maintenance Saving with 4000 Armstrong Traps

Here are the Benefits

- ***Quick Replacement of Traps*** **simply by uncoupling unions and installing a "spare" trap complete with nipples and half unions.**
- ***Bypasses Not Needed*** **—drain line can be shut off during quick trap replacement, even on critical equipment.**
- ***Repair Parts Inventory Reduced*** **by standardization on one make of trap.**
- ***Purchasing Simplified*** **through standardization.**
- ***Maintenance Men Become Experts*** **on one make of trap.**
- ***Armstrong Traps Last Longer*** **with less maintenance.**

ORIFICE SIZES	
PRESSURE	SIZE
0-40	7/16
40-60	5/16
60-150	7/32

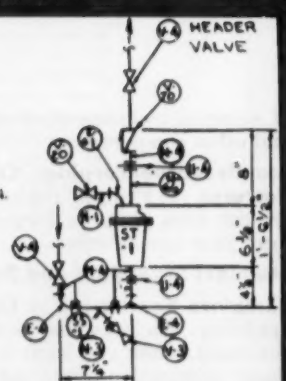
CAPACITY-0-300#/HR

NOTES:

DIMENSIONS SHOWN ARE FOR MINIMUM SPACE INSTALLATION.

IN LONG RUNS - PIPE TO BE PITCHED TOWARD TRAP.

TRAP TO BE INSTALLED BELOW DRAIN POINT IF POSSIBLE IF NOT POSSIBLE, A CHECK VALVE MUST BE INSTALLED ON INLET SIDE OF TRAP



BILL OF MATERIAL FOR TYPICAL STEAM TRAP HOOK-UP

MARK	REQD	MAT'L	DESCRIPTION
ST-1	1	ELEM. ST. CAST IT.	1/2" STEAM TRAP - ARMSTRONG #211
SS-1	1	CAST IT.	1/2" STRAINER - 250# W.S.P. -
V-4	2	BRZ	1/2" GATE VALVE - SCRD - 200# W.S.P. -
V-20	1	BRZ	1/2" GLOBE VALVE - SCRD - 200# W.S.P.
V-3	1	BRZ	1/2" GATE VALVE - SCRD - 200# W.S.P. -
V-70	1	BRZ	1/2" CHECK VALVE - SCRD - 200# W.S.P. -
E-4	2	MALL. IRON	1/2" - 90° SCRD ELL - 2000#
E-41	1	MALL. IRON	1/2" - 90° STREET ELL - 3000# -
U-4	2	MALL. IRON	1/2" UNION - 2000#
N-1	1	STL	1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-3	1	STL	1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4	6	STL	1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4/4	1	STL	1/2" - 4" LG. NIPPLE - SCH 80 - SEAMLESS ASTM A-53

MAJOR REDUCTIONS in steam trap installation and maintenance work and cost can be achieved by standardization on one make of trap which, in turn, permits standardized hookups. For example, a major chemical company reports an annual maintenance saving of $25,000 since installing 4000 Armstrong traps according to the drawing and photographs shown here.

Traps of a Size Interchangeable

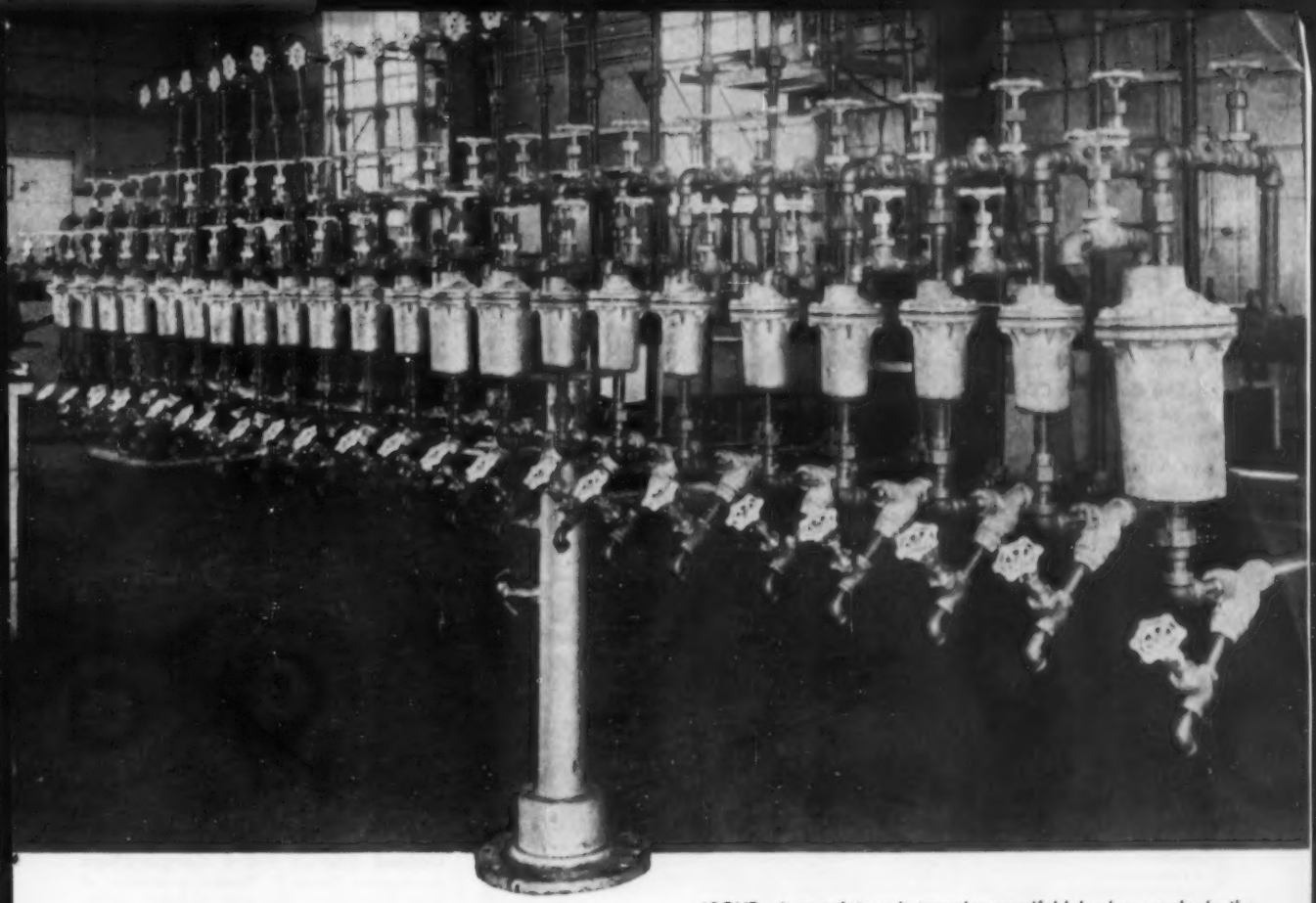
Note particularly that exact dimensions are given for the pipe fittings, including nipples, connected to each size of trap. When a trap needs repair, the unions can be uncoupled, the trap lifted from the line, and a "spare" carrying indentical length nipples and half-unions slipped in place. Thus, in as little as one or two minutes, a faulty trap is replaced. It is then returned to the storeroom for repair and takes its place as a "spare."

Additionally, each trap hookup offers the following time and cost-saving advantages:

1. Test valve in trap cap to permit fast, easy checking of trap operation so that any failure can be quickly detected to avoid waste.
2. Strainer ahead of trap to protect it against dirt and scale.
3. Blowdown valve in strainer to provide easy cleaning.
4. Check valve in discharge line to isolate trap when test valve is opened.
5. Shut-off valves and unions ahead of and following trap to permit removal of entire trap from line.

No Bypasses

Because of the rapid spare trap interchangeability, there is no need for bypasses to keep a unit in operation in event of trap failure. The cost of bypass installations is avoided, as is the waste that occurs when bypasses are in use, or accidentally left open. (Experience indicates that bypasses are often left open *not* due to trap failure, but due to reducing valve failure which allows steam pressure to exceed maximum trap operating pressure.)



ABOVE: A complete unit trapping manifold hookup made in the customer's piping shop. Note unions, shut-off valves, test valves and strainers for easy maintenance.

Condensate Headers

Another installation technique which saves installation and maintenance cost is the use, wherever possible, of trap manifolds. Traps and manifolds can be assembled in the plant pipe shop under ideal conditions for good workmanship and minimum time consumption. After assembly the manifolds are taken to the site of installation where lines from units in the vicinity are run to the traps. Traps are thus grouped where they can be found easily and where they are readily accessible for inspection and maintenance.

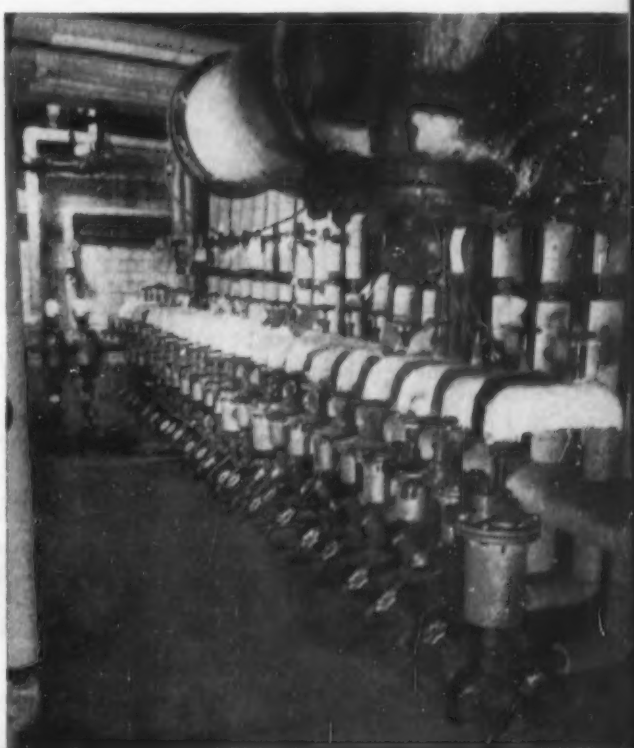
$25,000 Trap Maintenance Saving

Records kept on the Armstrong trap installation described here show that the cost of repair parts and complete replacement traps was approximately $10,000 less annually than with the traps previously used. Reduction in maintenance labor brings the total saving to $25,000 per year. *And fuel savings attributable to the traps are at least equal to the maintenance saving.*

FOR COMPLETE INFORMATION, ask for the No. 1, 1956 issue of the Armstrong Trap Magazine, together with a copy of the Armstrong Steam Trap Book containing complete data on Armstrong traps plus selection, installation and maintenance recommendations. Call your local Armstrong Representative or write:

ARMSTRONG MACHINE WORKS
852 Maple Street • Three Rivers, Michigan

BELOW: Installation view of trapping hookup pictured above. All traps easily accessible for inspection and maintenance.



FRICK

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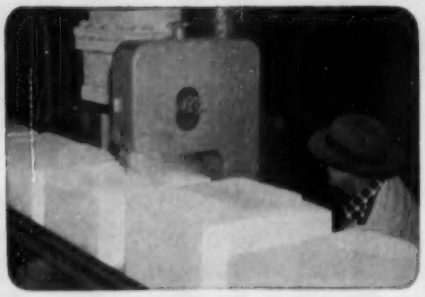

The Colorado CO_2 Corp. produces up to 50 tons of solid carbon dioxide daily in its $2½-million plant near Las Animas, Colo.

The gas, obtained from wells 5 miles away, is condensed, subcooled, and solidified at 109 degrees below zero F. with a new Frick-engineered cycle operating at very economical pressures.

Practically all the mechanical equipment in the plant was furnished and installed by Frick Company. Another example of the COMPLETE engineering service that is yours when you purchase Frick air conditioning, ice making, quick freezing or other refrigerating equipment. Let us quote you now on your requirements.

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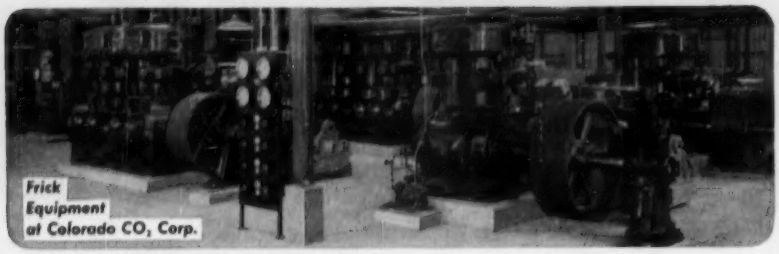

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Suppliers . . .

ager. He thus heads Graver's national sales organization for steel and alloy tanks and vessels, both shop-built and site-erected. Though his headquarters will be at the Graver plant in East Chicago, Indiana, he will spend much of his time in sales offices throughout the country.

An engineering graduate of Cornell, he has been with Graver for 15 years, mostly in New York, where he was manager of eastern sales.

Hills-McCanna Company, Chicago, announced the appointment of **Sager-Spuck Company,** Albany, New York, as stocking distributor for Hills-McCanna diaphragm valves and replacement parts in the eastern portion of New York.

Leeds & Northrup Company, Customer Training Center, issued to chief instrument engineer **Hassan Manavi** of the Iranian Oil Refining Company, Abadan, Iran, the first formal Certificate of Completion.

Mr. Manavi is a graduate mechanical engineer and heads an instrument department of about 380 men in the 650,000 bbd refinery. He has spent several weeks in this country familiarizing himself with American instruments and other equipment, and has also spent considerable time in Europe on the same work.

Presentation of the certificate was made by **George C. Graf** of L&N.

United States Steel Corporation has named **James E. Brown,** a veteran of over 25 years in the wire business, to the top post of American Steel & Wire's Cyclone Fence department. His promotion to vice president of the Wire Division and general manager of Cyclone Fence was announced by Walter F. Munford, president of this division of U. S. Steel Corporation. Since September, 1950, Brown has been general superintendent of the Waukegan, Ill., plant.

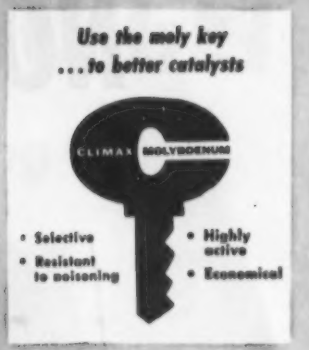
At the same time, appointment of **Frank E. Kyndberg** to general sales manager of Cyclone Fence Department was also announced. Kyndberg will direct the activities of Cyclone's sales department, operating throughout the country and selling chain-link fence.

Vernon L. Strohm, a 33-year veteran of American Steel & Wire, and division superintendent of the Waukegan wire mill, succeeds Brown at Waukegan.

Selas Corporation of America has organized its staff of research engineers into four basic laboratory teams, according to an announcement by F. O. Hess, president. The following are the teams organized under the direction of **A. A. Furczyk** as department head, with **J. B. Henwood** as administrative supervisor: Applied Research, sponsored investigations, special combustion process projects, and development of improved combustion equipment; Scientific Research, mathematical and physical investigations of heat transfer, fluid mechanics, and other theoretical considerations of combustion; Customer Inquiry Research, development of specific processes employing advanced combustion techniques; and Metallurgy, general investigations of metal treating processes.

Supporting these teams are a chemical laboratory, ceramics laboratory, a group of laboratory design engineers, and a re-

For more data on advertised products, use Readers' Service Cards, last page.



Moly catalysts resist poisoning

When sulfur is removed from petroleum stocks, the catalyst must resist poisoning. It must withstand contamination from sulfur and *also* from nitrogen and metallic contaminants.

Cobalt molybdate catalysts, in a number of different commercial processes, are the answer to these difficult specifications. Stocks up to 3 to 4% sulfur by weight have been processed. When stocks with less sulfur are used, products containing as little as 0.1% sulfur are obtained. Yields are almost 100% of theoretical.

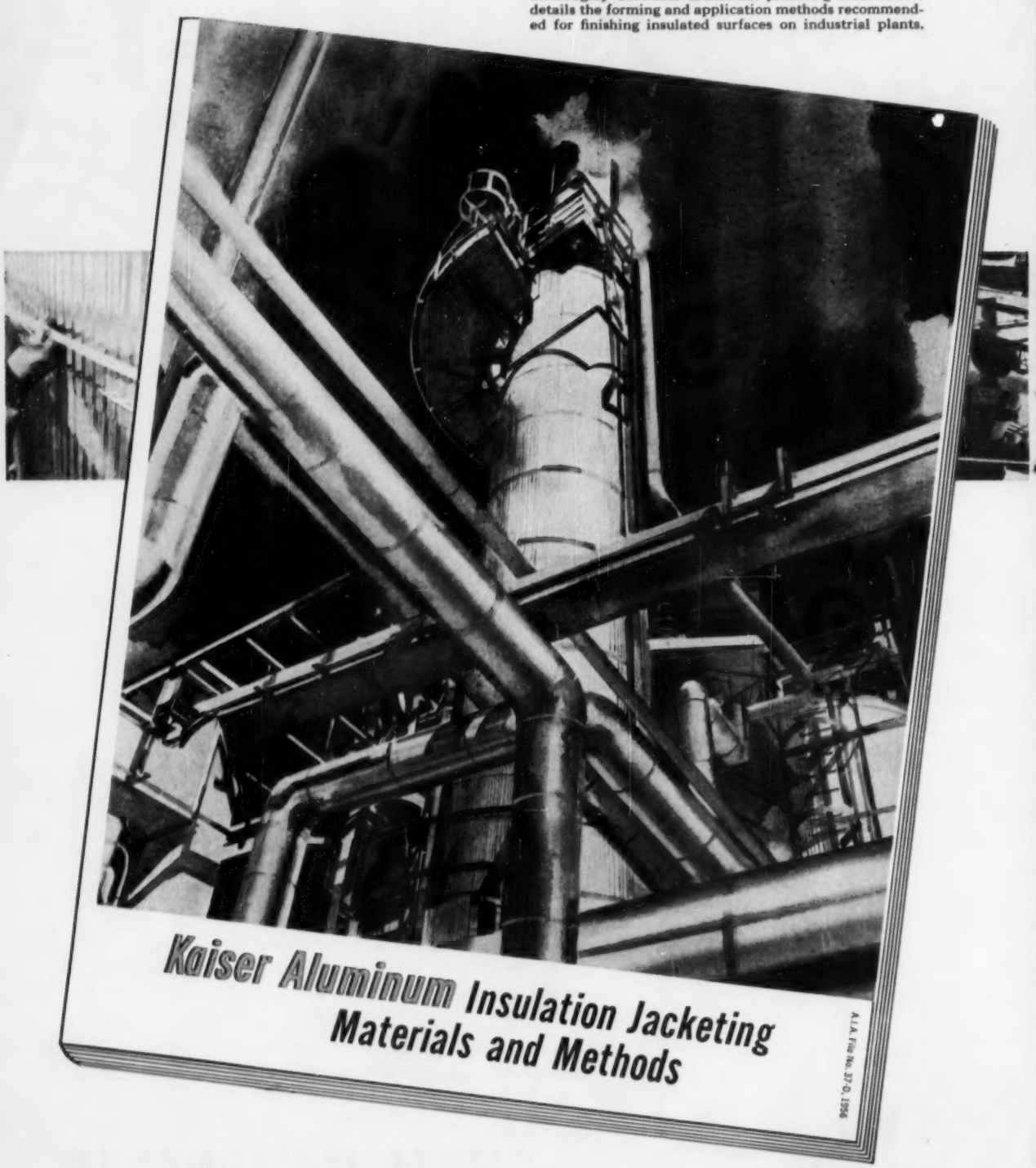
For technical data about molybdenum catalysts write for our bulletin "Molybdenum Catalysts for Industrial Processes." Dept. 25, Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

NOW... NEW MANUAL

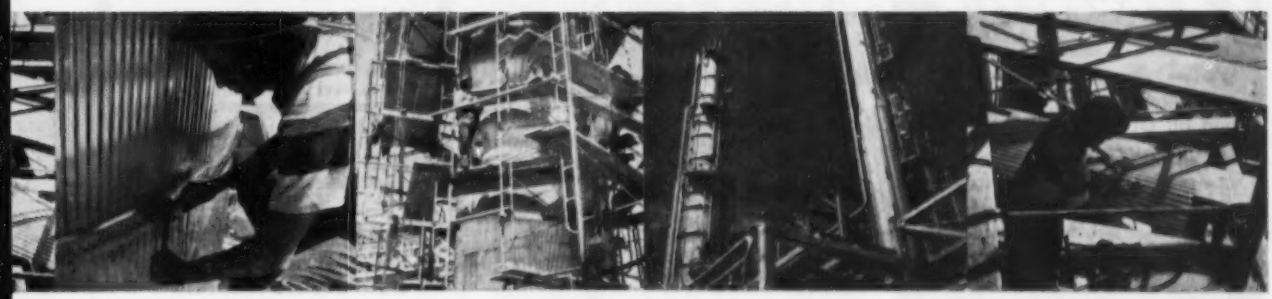
40 PAGES—FULLY ILLUSTRATED

Thoroughly describes aluminum jacketing materials... details the forming and application methods recommended for finishing insulated surfaces on industrial plants.



SHOWS YOU HOW TO GET

✓ Complete Insulation Jacketing
✓ Longer Jacketing Life
✓ Improved Appearance
✓ Lower Cost



Plant designers, contractors and owners can now take advantage of newly-developed methods for getting more complete coverage of insulation with aluminum jacketing.

This new Kaiser Aluminum manual makes available —for the first time—*complete information on the subject of aluminum jacketing.*

Emphasizes Complete Coverage

Besides showing methods for jacketing tanks, vessels and straight runs of piping, the manual shows how to jacket fittings and heads—elbows, T's, valves, flanges, reducers, branch connections, expansion couplings, tank roofs, outlets and flat, dished and conical heads.

And because these methods include adaptations of the construction industry's efficient "dry wall" techniques, they give you these other important advantages: faster, safer application, lower costs, neater installations that require less cleanup.

On-the-job Techniques Illustrated

Photographs and tables throughout show typical examples of how Kaiser Aluminum is applied in actual industry situations. Drawings and diagrams provide details of expansion joints, pipe jacketing, flashings, insulation and jacketing support arrangements for vertical walls and for storage tank roofs.

Snap Jacket Introduced

The manual introduces *snap jacketing*—refinements of proven techniques developed from Kaiser Aluminum's "idea partnership" with customers. Using these new techniques, one man working alone can quickly apply weather-tight jackets to piping.

Send the coupon today and get your free copy of this valuable manual. And for immediate assistance on any jacketing requirements, call the Kaiser Aluminum sales office listed in your telephone directory. Process Industries Department, Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

materials for the process industries

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KAISER ALUMINUM & CHEMICAL SALES, INC.
Process Industries Department, Room 71111
1924 Broadway, Oakland 12, California

Please send my copy of your new manual "Kaiser Aluminum Insulation Jacketing Materials and Methods." I understand there is no obligation.

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Write today for the Schotco story

SCHOTT BROS. CO. INC.
WEST SALEM, OHIO

Suppliers . . .

cently augmented pool of laboratory technicians.

Minneapolis-Honeywell Regulator Company has elected **W. W. Gilmore** a vice president. He is president of the company's Micro Switch division in Freeport, Ill., and will continue to hold that post.

Gilmore, a native of Missouri, established his own industrial consulting firm in Chicago in 1922 and it was in that capacity that he first became associated with the Freeport, Ill., firm in 1941 as industrial engineering consultant to help the company prepare for wartime production.

During World War II he advanced from management engineer to executive vice president and became president when the firm was a subsidiary of the First Industrial Corporation, which was a subsidiary of the Commercial Investment Trust. In 1950 it became Honeywell's Micro Switch division and Gilmore remained as president.

Olin Mathieson Chemical Corporation, Little Rock, Ark., has granted the University of Missouri a research grant of $7,500 in support of fundamental research to be conducted in the Department of Soils, College of Agriculture. Called "A Study in Energetics of Ionic Relations in Soils and Plants," the project is designed to determine through physical chemistry the difference in energy by which chemical reactions send nutrients from soil to plant root and from the root to the soil.

TEMPORARY STRAINERS

Made by a skilled mechanic and not by "just some guy with a torch."

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Established 1901

REVOLUTIONARY CONSTRUCTION

Smooth, efficient contours . . . no weld "blob" around edge of ring. The flange is precision rabbeted into the ring joint gasket making deformation at that point impossible.

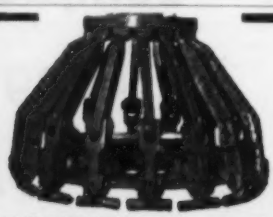
MAC-IRON offers a complete listing of line and temporary strainers. The latter of woven wire, perforated basket and conical . . . all for use with raised face, and ring joint flanges. A large stock on hand is maintained; special strainers made to specification.

Also producers of MAC-IRON Blinds and Spectacle Blinds (Figure 8). Available for use with various types of flanges in all pipe sizes and pressure ratings.

WRITE FOR COMPLETE INFORMATION

The Mack Iron Works Company
Warren and Water Sts. Sandusky, O.

Evans Research and Development Corporation has added three more chemists to its technical staff. All research chemists. They are **Gerald Fishman**, formerly of Affiliated Research, Inc.; **Miss Ruth Fierman**, formerly of Jacobs Winston Laboratories, and **Stanley Lerner**, formerly of Columbia University.



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Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

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Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000 F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

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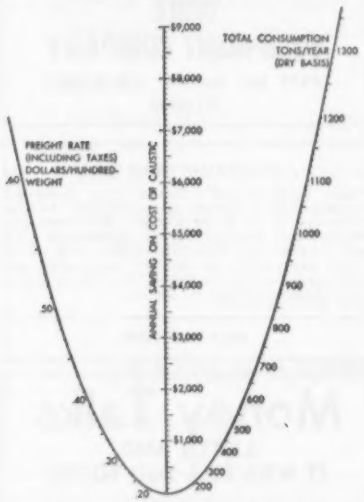
BRIEFS
for heavy-chemical buyers

50% or 73% Caustic? Choosing a supplier Air-conditioned $AlCl_3$

50% to 73%— some save, some don't

To estimate quickly whether you can save by switching from 50% to 73% liquid caustic soda, simply draw a line on this nomograph.



Start at your freight rate and draw to your annual consumption in tons, dry basis. Your approximate savings on freight will appear where you intersect the center line.

From this figure, subtract annual depreciation for dilution equipment. (We'll be glad to advise you on cost of this equipment.)

If you still show a saving, it would be wise to consider the big switch seriously.

For more facts on the economics of 50% and 73% caustic, check the coupon for a copy of our pocket-size *Caustic Soda Buyer's Guide.*

And for specific technical advice centered on *your* requirements, just phone or write the nearest Hooker sales office.

Choosing a supplier

Service is a large part of what you pay for when you buy caustic soda.

Here are some important "service" points to look for when you're considering a source of supply. (As a Hooker customer, you enjoy *all* of them.)

1. Supply security. How flexible are your supply lines? For instance, a supplier with plants and stock points on deep water may be able to offer you a choice of rail or water delivery. This can assure you steady supply in case of rail service interruption.

2. Realistic contracting. Your agreements with your supplier should realistically reflect your expected needs *and* the supplier's ability to consistently deliver the tonnage you need. Best yardstick for measuring this ability is a supplier's performance record. Hooker, for example, has an unbroken 50-year record of fulfilling contract commitments.

3. Engineering help. A supplier's engineering staff can help you set up a new caustic handling system—or revamp an old one—with advice, and with actual design assistance.

4. Safety programs. The men in your plant who handle caustic soda can benefit from safety suggestions offered by your supplier. You should have on tap the latest in safety equipment, plus up-to-date information on the safe handling of caustic soda.

We'd be happy to enlarge on these points, with your caustic requirements in mind. A phone call or note to the nearest Hooker sales office will bring you the specifics.

Why we air-condition our aluminum chloride.

Even slightly humid air reacts swiftly with aluminum chloride. When it does, the crystals of this sensitive chemical lose their shape, and most of their punch as catalysts.

We avoid such damage to our aluminum chloride by using a special air-conditioned packaging room. It gives us complete control over humidity. Regardless of outside weather conditions, we can package aluminum chloride all year 'round.

To you the room means a continuous, dependable supply of full-strength aluminum chloride. And you always get the size you want for your process.

Speaking of size, you have a choice of four from Hooker—extra fine, fine and coarse grinds, and coarse screened. Send the coupon for a data sheet that gives complete specifications on all four, or write today on your business letterhead.

Check items you'd like to receive:

☐ *Caustic Soda Buyer's Guide.* Lists advantages of 50% and 73% solutions; comparative costs; capacities of tank cars and other containers; useful shipping information.

☐ Technical data on caustic soda.

Need information on these other Hooker products used in the petroleum industry? Check here for technical data sheets:

☐ Aluminum Chloride, anhyd.
☐ Antimony Trichloride
☐ Muriatic Acid
☐ Sulfur Chlorides

Clip and mail to us with your name, title, company address.

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HOOKER ELECTROCHEMICAL COMPANY

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For more data on advertised products, use Readers' Service Cards, last page.

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Chemists
Physicists
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For employment in a new petrochemical plant near Houston. Modern well equipped laboratory. Principal products are butadiene and avgas. Experience in hydrocarbon analysis desirable. Send resume including details of education, experience, and salary requirements to C. E. Leach—

TEXAS BUTADIENE & CHEMICAL CORPORATION

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Esso Engineering Is Expanding
Chemical Engineers Needed

Career openings available in long range expansion program. Work involves process planning, economics, design, and occasional field follow-up.

Prefer men of high scholastic rating and with one to seven years experience. There are also a number of openings for very recent graduates. Both Bachelors and Masters degree positions are available. Salary commensurate with experience and qualifications.

If you are interested in an opportunity for growth and promotion with a leader in the petroleum industry, write today giving full details of education, experience, salary desired, availability date and references.

All inquiries will be considered promptly and held confidential.

Esso Research and Engineering Company

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SITUATION WANTED

MR. EXECUTIVE: Young man seeks administrative position as assistant to top executive in U. S. or abroad. Excellent personality and diligent worker. Degrees in LAW and CHEMICAL ENGINEERING with eleven years experience in refinery economics and petroleum processing fields. Box 249-R, Petroleum Refiner, Houston, Texas.

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Engineers Are in Demand

in the Gulf Coast Area. Our experience means quicker results. Salaries $6,000 to $12,000 up.

Sales Engineer

Manufacturers representative requires young chemical or mechanical engineer with process experience to sell process equipment to Gulf Coast Refineries and chemical plants. Participate substantially in steady growth of small company. Replies confidential. Give short resume for interview.

THE RAINEY COMPANY
P. O. BOX 6453, HOUSTON 6, TEXAS

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THE READER'S SERVICE CARD

HELP WANTED

PETROLEUM ENGINEERS

SENIOR ENGINEERS

Graduate Engineers with minimum seven years experience in all phases of Producing Operations including Reservoir Engineering, pressure maintenance, secondary recovery, and all types of primary depletion plus some knowledge of facility requirements. Initial assignment will be in New York Office in newly organized specialty study group concerned with long range planning of Arabian operations. Salary commensurate with background and experience.

GRADUATE ENGINEERS

Electrical, Mechanical, Chemical or Petroleum Engineers with minimum two years experience in Petroleum Production Reservoir field who are interested in Production Reservoir Engineering and Reservoir Exploitation. Initial assignment New York Office. Salary commensurate with background and experience.

DRILLING

Graduate Mechanical or Petroleum Engineers with minimum five years experience. For exploration and producing operations in Saudi Arabia. Salary open, plus liberal living allowance.

Write giving full particulars regarding personal history and work experience.

Recruiting Supervisor, Box 191

ARABIAN AMERICAN OIL COMPANY

505 Park Avenue **New York 22, N. Y.**

HELP WANTED

PROCESS ENGINEERS with Eight or More Years Experience

Our Process Engineering Department has opportunities for several experienced engineers who wish to follow their preferred fields in petroleum refining or large volume petrochemical processing.

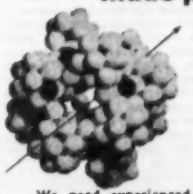
Assignments will be primarily process design and economics – determination of overall process requirements, selection of processing steps, and economic evaluation of processes. Other work may include market analysis, industrial surveys, and technical assistance to sales.

Write to the head of our Personnel Department, Mr F B Stratford.

C F BRAUN & CO
ALHAMBRA CALIFORNIA
Engineers
Consultants Constructors

REFINING PROCESSES

based on ADSORPTION
made possible with MOLECULAR SIEVES



—upgrading of gasoline

—drying and sweetening of natural gas

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We need experienced PETROLEUM CHEMISTS and CHEMICAL ENGINEERS to put the unique properties of Molecular Sieves to work in the Petroleum Industry.
Promising fixed and moving bed cycles under development both in adsorption and catalysis.
Submit resume including education (approximate academic standing), experience and background to:

LINDE AIR PRODUCTS COMPANY
a Division of
UNION CARBIDE AND CARBON CORPORATION
P. O. BOX 44, TONAWANDA, NEW YORK
Attention: Mr. R. P. Kalie
Refer to Ad: PR-PC

CHEMICAL ENGINEERS

Major Oil Company has openings for Chemical Engineers in several phases of process engineering. Locations near New Orleans and south Arkansas, in booming industrial areas where climate and natural advantages make living more enjoyable for all the family. Attractive salary and benefits program. In reply give age, education, experience and salary expected. Pan-Am Southern Corporation, P. O. Box 2, New Orleans 6, Louisiana.

More Classified Advertising on Next Page

HELP WANTED

PROCESS ENGINEERS

With three to six years experience

Several qualified process engineers can broaden their professional responsibilities in our Process Engineering Department. They will design a wide variety of plants for petroleum refining and large volume petrochemical processing.

Assignments range from complete integrated refineries and chemical plants through all types of individual process units. The work includes heat and material balances, and computations for unit operations such as fractionation, heat-transfer, absorption and extraction.

Fine facilities, top salaries, new retirement plan. Write to the head of our Personnel Department, Mr F B Stratford.

C F BRAUN & CO
ALHAMBRA CALIFORNIA
Engineers
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CHEMICAL ENGINEERS

Foreign Employment

For career assignments in technical service and research and development work in a large modern refinery installation in Saudi Arabia. Excellent opportunities for diversified experience and advancement assured by complexity of present installation and future expansion.

Liberal all-inclusive benefits. Opportunity to travel on long vacations and live in modern community with complete facilities including extensive recreation.

Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 177
ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

HELP WANTED

OPPORTUNITY

Supervisory research opening in Lion Oil, A Division of Monsanto Chemical Company for qualified person with at least 5 years experience in the formulation of petroleum products and non-automotive petroleum specialties. Refining experience desirable but not essential. Location El Dorado, Arkansas. Integrated refinery operations of moderate size. Real opportunity for advancement.

Address replies to:

E. R. Coley
Technical Recruitment Coordinator
Lion Oil Company, A Division of
Monsanto Chemical Company
El Dorado, Arkansas

RESEARCH CHEMIST

Major Oil Company in Mid-Continent area has opening for chemist. Applicants must have a Ph.D. in chemistry or 3 to 5 years experience in organic research. Give resume of experience, references and salary expected.

Apply reply to: Refinery Personnel
P. O. Box 381
Tulsa, Oklahoma

PATENT ATTORNEY with chemical and law degrees and two to three years patent prosecution experience is desired by chemical manufacturing company located in south central U. S. Excellent opportunity for advancement. Please furnish information giving age, education, experience and salary desired. Address replies to Box 244-R, Petroleum Refiner, Houston, Texas.

MECHANICAL ENGINEER OR CHEMICAL ENGINEER

Degree in Mechanical or Chemical Engineering with two or more years experience on high pressure equipment preferred though not required. Permanent position on staff of a progressive chemical company located in Tuscola, Illinois. Liberal personnel benefit program. Send resume of background and qualifications to:

National Petro Chemical Company
Attention: Personnel Department
P. O. Box 109
Tuscola, Illinois

HELP WANTED

CHEMICAL ENGINEER

An expanding program in the new and extensive facilities at Parma, Ohio, requires a chemist or chemical engineer with training or experience in petroleum refining or coal hydrogenalysis procedures for research and engineering in the field of utilization heavy residues.

As the newest of several major research centers of Union Carbide and Carbon Corporation, the Laboratories at Parma also offer excellent opportunities for research in Solid State Physics, Electrochemistry, and High Temperature Chemistry, Carbon and Graphite.

Mail resume and college transcripts to:

G. H. Murray, Jr.
Personnel Director
National Carbon Research Laboratories
P. O. Box 6116
Cleveland 1, Ohio

NORTHERN CALIFORNIA REFINERY PROCESS ENGINEER

Combine challenging, unlimited-future job with ideal, smog-free living in San Francisco-Oakland Bay Area. Excellent salary, moving allowance, profit sharing plan and retirement, family plan hospitalization and life insurance. Must have B.S. or M.S. in chemical engineering, plus at least 10 years experience in process design with major oil company or refinery builder. Forward complete resume giving experience and salary requirement. Strictest confidence.

ALSO OPENINGS FOR REFINERY DESIGNERS AND ESTIMATORS.

KAISER ENGINEERS
Division of Henry J. Kaiser Co.
Dept. RN, 1924 Broadway
Oakland 12, California TWinoaks 3-4600

PETROLEUM REFINING SPECIALIST

Position open in Refinery Technology Division, which carries out fuel evaluations, Refinery Studies, and other technical service projects for petroleum refiners. Requires B.S. or M.S. Degree in Chemical Engineering plus 2 to 5 years experience in refinery operations such as cracking, reforming, light ends, blending, and/or economic analysis. Position offers a wide variety of work assignments, contact with persons in process companies and customer companies, and an opportunity for individual expression and responsibility in an expanding activity. Ideal location in Detroit suburb couples attractive working conditions with a choice of City or Suburban living.
Send resume of qualifications to:

Ethyl Corporation Research Laboratories
1600 West Eight Mile Road
Ferndale 20, Detroit, Michigan
Attn: Personnel Manager

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Sr. Draftsmen
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Classifications:

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Structural
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Type of Design:

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Industrial Plants
Steam Power Plants
Petroleum Refineries
Electrical Sub-Stations
Hydro Electric Projects

Send Resume to
Manager of Employment & Placement
Industrial Relations Division

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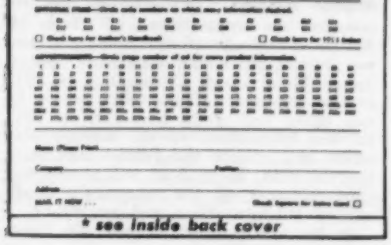
CORPORATION
220 Bush Street
San Francisco 4, Calif.

For an immediate personal interview you may phone:
Paul Keating, Plaza 7-4400, New York City
Joe Braddick, Fairfax 3-2401, Houston, Tex.
Bill Milligan, Tucker 1549, Los Angeles, Calif.
Don Palmer, Douglas 2-4032, San Francisco, Calif.

use these
READERS' SERVICE CARDS* for more information



* see inside back cover

HELP WANTED

CHEMICAL and MECHANICAL ENGINEERS:

There are outstanding career opportunities with one of the 100 largest corporations in the United States for men with the following qualifications:

- One to five years experience in petroleum refining or related activities.
- B.S. or higher degree and experience:
  (Chemical) in development, pilot plant operation, process design, process trouble shooting, refinery process engineering, economic studies or related work.
  (Mechanical) in process equipment construction, design, inspection, or maintenance, petroleum product testing and field evaluation or related work.
- Age range . . . 22-32.

Choice positions open in Cleveland, Toledo and Lima, Ohio.

Write, giving a complete resume of your education, experience and personal data to:

CLYDE A. BRUGGERS
1737-F Midland Building, Cleveland 15, Ohio

There's a bright future waiting for the right men with

THE STANDARD OIL COMPANY (OHIO)

SPECIAL PETROLEUM REPRESENTATIVE

Established manufacturer of industrial processing materials has opening for a special representative in the Great Lakes Region.

Applicants must be 25-40 years of age, and must have petroleum refinery experience in the mechanical, engineering, processing, or operations department. 60% travel, salary, plus expenses.

This is an unusual opportunity for a capable man looking for permanency and above average earnings.

Reply giving full details of education, background, and personal status to Box 247-R, PETROLEUM REFINER, Houston, Texas.

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They Pay

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RELAYING RAILS
Handle more cars better—cost less to install and maintain. Foster stocks all Rail Sections 12# thru 175#, Switch Material and Track Accessories.
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For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Petroleum Analytical-Research Corporation announces Arnold E. Williams, formerly with Eastern States Petroleum Company, as president of this newly-formed company. The company will offer mass spectrometer analysis service. With this and other analytical tools, they will provide a complete analysis service wherein crude oil and distillates may be evaluated, vapor and liquid streams analyzed, and natural gas composition determined. The company will also furnish mass spectrographs and calibration data should the customer have personnel qualified to calculate the final results. The company is located on the Gulf Freeway, Houston, Texas.

Acme-Hamilton Rubber Manufacturing Corporation, Trenton, N. J., announced the appointment of **William McNeil** as manager of its New York district sales office.

McNeil was associated with Harnischfeger Corporation for eight years as sales engineer covering New York and New England territories, and prior to that with Gates Rubber Company as a sales engineer in their Boston territory.

Beckman Instruments, Inc., has appointed **Ralph S. White** as manager of research and engineering for the Spinco division in Belmont, Calif. White transfers to the new Spinco post from Stamford, Conn., where he served as assistant manager of the Liston-Becker plant of Beckman's Scientific Instruments division.

Holder of a bachelor's degree in mechanical engineering from California Institute of Technology and a master's degree in business administration from Stanford University, White has been with the Beckman organization for six years.

B-I-F Industries, Inc., has transferred **Theodore R. Zatkovich** from Pittsburgh to Chicago to take over the duties of district sales manager. The Chicago sales territory includes offices in Chicago, Milwaukee, Indianapolis and Kansas City. Zatkovich will be in charge of both industrial and municipal sales.

Olin Mathieson Chemical Corporation has added **Dr. Sylvan I. Cohen** as an agricultural research specialist in the research and development department of the Insecticides division at Port Jefferson, New York. He was formerly vice president for research of Gallowhur Chemical Corporation, Ossining, New York.

Dr. Cohen obtained his Ph.D. degree in plant pathology at Washington State College, Pullman, in 1942. Much of his work has concerned the development of mercurial seed disinfectants and other new organic foliage fungicides. He holds patents on several compounds developed for use in this field.

Parker has appointed **Hydraquip Corporation,** Houston, Texas, as distributor of Parker tube and hose fittings and tube-working tools. Stocks of Parker products will be maintained at Hydraquip for servicing customer requirements throughout the industrial Gulf Coast area.

H. K. Porter Company, Inc., Lacleede-Christy Company Division has appointed **James E. Hays** Indianapolis sales representative. His territory includes central Kentucky, southwest Virginia, western Ohio, southern Indiana, and southeastern Illinois.

Previously, Hays was Furnace Engineer for Foster Forbes Glass Company. He is an engineering graduate of Purdue University and a member of the Marion, Indiana, Engineers Club.

Arthur G. McKee & Company, steel division, was transferred this week to the company's newly completed building in Cleveland.

The new engineering building, completed last month at a cost in excess of $500,000, contains about 25,000 square feet of floor space, and is of steel frame construction with provision for the future construction of two additional stories.

It is part of McKee's program of expanding its home office and engineering facilities to take care of the growth in the volume of new business.

ACF Industries, Inc., has named **Gregory J. Asbee** manager of pressure vessel sales for its American Car and Foundry Division. Asbee joined ACF in 1954 as eastern district sales manager. He has had 26 years' experience in the pressure vessel field.

Air Reduction Company has elected **David H. Lyall** treasurer succeeding **Howard H. Foster** who has resigned. Lyall, with the company for 21 years, became general auditor in 1944 and has been assistant controller since 1949.

Magnetrol, Inc., announced that **B. L. Binford,** formerly chief engineer, has been elected vice president in charge of manufacturing.

Metal Goods Corporation has announced the appointment of **Clark M. Brown** as manager of the company's Denver district office and warehouse. Brown joined Metal Goods Corporation in 1947 at the company's Tulsa office where he was office and credit manager. In 1951 he was transferred to the Kansas City office, and became the district sales manager in 1954. In 1955 he was named district manager of the company's newly opened Wichita office and warehouse.

In his new position, Brown will direct

HELP WANTED

REFINERY ENGINEERING in Southern California

Several qualified graduate engineers — Chemical, Mechanical or Petroleum — can broaden their professional responsibilities in our Chemical Engineering Department.

Assignments will cover the application of processes to a wide variety of industrial plants, ranging from complete integrated refineries and chemical processing centers through all types of individual process units. The work includes coordination of chemical engineering, the selection and design of process equipment and machinery, and startup of completed plants.

Top salaries, fine facilities, profit-sharing retirement plan. Write to the head of our Personnel Department, Mr F B Stratford.

C F BRAUN & CO
ALHAMBRA CALIFORNIA
Engineers
Consultants Constructors

HELP WANTED

PROJECT LEADER Chemical Engineer

A challenging position to open for an experienced Chemical Engineer to act as project leader. This position is concerned with pilot plant design, construction, and operation.

This position requires a man with a degree in Chemical Engineering and extensive experience in moderately high pressures.

You may use your initiative and creative ability and work with other leading scientists in this field.

We offer excellent employee benefits, opportunity for advancement, and a good salary. Please send resume to:

Mr. J. A. Metzger
ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

CHEMICAL-or-MECHANICAL ENGINEER

Age Under 35. Petroleum Refinery Exp. Desirable.

Technical work in small expanding department of a MAJOR OIL CO. New York City location with some travel entailed.

Excellent opportunity for man with initiative. Salary commensurate with experience. Fine employee benefit program.

Send full qualifications together with resume to Box 246-R, PETROLEUM REFINER, Houston, Texas.

all activities of the Denver district office and warehouse. The company is now building a new warehouse and office in Denver, which will double the company's warehousing capacity for Denver.

Monsanto Chemical Company, Inorganic Chemicals division has organized separate sales sections for agricultural chemicals and industrial chemicals within the sales department. At the same time, the organization of the division's research department has been aligned to provide strengthened research activity, particularly in connection with those phosphorus and nitrogen products of the division which are raw materials for various segments of the agricultural industry.

The move in both departments is the result of consolidation in the division for sales and research on nitrogen products, previously handled by the Lion Oil Company division.

Anderson

Juengling

Armco Steel Corporation has announced the retirement of two top executives of its Sheffield Division. **J. W. Anderson,** president of the Sheffield Division, and **F. C. Herbster,** works manager of Sheffield's Kansas City plant, have retired.

L. H. Juengling of Houston, formerly secretary and assistant to the divisional president of Sheffield, has been elected a corporate vice president in charge of Sheffield activities.

R. F. Kuhnlein, former assistant works manager of the Kansas City plant, will succeed Herbster as works manager.

The retirement of another veteran Armco executive was also announced. He is **L. F. Reinartz,** vice president in charge of special operating development, who served for many years as manager of the Middletown works.

Also announced was a change in the basic plan of organization of Armco Steel Corporation. The company's steel-making operations now will be carried on under two separate divisions—the Armco Division under the management of **R. S. Gruver,** a vice president, and the Sheffield Division under Juengling.

Perkin-Elmer Corporation has appointed three product line sales managers for its Instrument Division. They are **John H. Rhodes,** sales manager for laboratory analytical instruments; **Edward C. Berndt, Jr.,** sales manager for process control instruments; and **Vincent J. Coates,** manager for application engineering and special engineering sales.

Robertshaw-Fulton Controls Company, Fulton Sylphon Division, is offering four year scholarships to the University of Tennessee valued at $2200 each, to three outstanding high school grads.

The company, in making the scholarships available said it wishes to encourage students to enter the field of mechanical or electrical engineering. Winners are obligated to continue with the study of the mechanical or electrical engineering course for the remaining three years to continue to qualify for the scholarship. They are under no obligation to accept employment with the company after graduation. Similar scholarships will be awarded each year.

Rockwell Manufacturing Company has added **Charles A. Ernst,** former assistant personnel manager of Sheffield Corporation, Dayton, Ohio, as headquarters personnel manager in Pittsburgh.

A native of Dayton and 1940 graduate of Ohio Wesleyan University, Ernst served as personnel director of Sinclair College, Dayton, before joining Sheffield in 1950. He majored in personnel administration and economics at Ohio Wesleyan, later received specialized training at Sinclair and the University of Dayton.

Chain Belt Company, Milwaukee, Wis., has announced the acquisition of **General Road Machines, Inc.** of Niles and Newton Falls, Ohio. General Road Machines manufactures steel forms for concrete road, airport, curb and gutter and sidewalk construction; concrete finishing machines; and other concrete road building equipment.

Donald T. Heltzel, President of General Road Machines, will continue as General Manager, and **J. J. Marcello,** Vice-President of General Road Machines, will be Sales Manager.

United States Steel Corporation gathered 45 officials and sales engineers of its Oil Well Supply division from throughout the United States and Canada at the division's Witte Engine Works for a two-day sales promotion meeting.

K. O. Nilsson, Witte general manager, said the purpose of the conference was to bring the representatives, who are responsible for sale of an important part of the plant's output, up to date on the plant's oil field engine models, acquainting them with recent developments and plans for the future. During the meeting the visitors viewed production lines, and operation and laboratory testing of the various models, in addition to discussions of sales features.

Worthington Corporation has announced the acquisition of a west coast manufacturing plant as a further step in the company's expansion.

The facility is located in Alhambra, Calif., and will be operated as the Western Air Conditioning division of Worthington. Its products will include warm air furnaces and air handling equipment for air conditioning systems designed to fit the climatic conditions of the western and southwestern states.

The plant was acquired from Royal Jet, Inc. in exchange for Worthington common stock.

Beckman Instruments, Inc., has appointed **H. S. Stover** as eastern data and control systems representative for its Scientific Instruments Division. Stover will be based at Beckman's eastern regional offices in Mountainside, N. J. He will be concerned with the application of advanced electronic data systems to a variety of fields, from monitoring and control of chemical, petroleum and other industrial processes to engineering studies aimed at the development of aircraft, jet engines and nuclear reactors.

Stover is an engineering graduate of Stevens Institute of Technology, Hoboken, N. J.

Suppliers . . .

Mallon

O'Connor

Dresser Industries, Inc., board of directors, Dallas, Texas, has announced the elevation of the company's top officers. **H. N. Mallon** has been named to the newly-created position of chairman of the board and will remain as chief executive officer. **J. B. O'Connor,** formerly executive vice-president, succeeds Mallon as president.

Mallon has been associated with Dresser since 1929 when the company became publicly owned. He has been principally responsible for developing and carrying out Dresser's program of growth and diversification.

O'Connor, with Dresser since 1937, previously was associated with Clark Bros. Co., a large Dresser subsidiary, for several years before its acquisition by Dresser. He was made executive vice-president in 1944, and has assumed particular responsibility for Dresser's engineering and sales efforts.

Manning, Maxwell & Moore, Inc., Industrial Controls Division, has announced the addition of **Walter A. White** as sales engineer in the Chicago district. White has many years' experience in the instrumentation field, and has been with Brown Instrument, Energy Control Corporation, and Charles Englehard, Inc. He joins Manning, Maxwell & Moore from Wheelco Instrument division of Barber Colman.

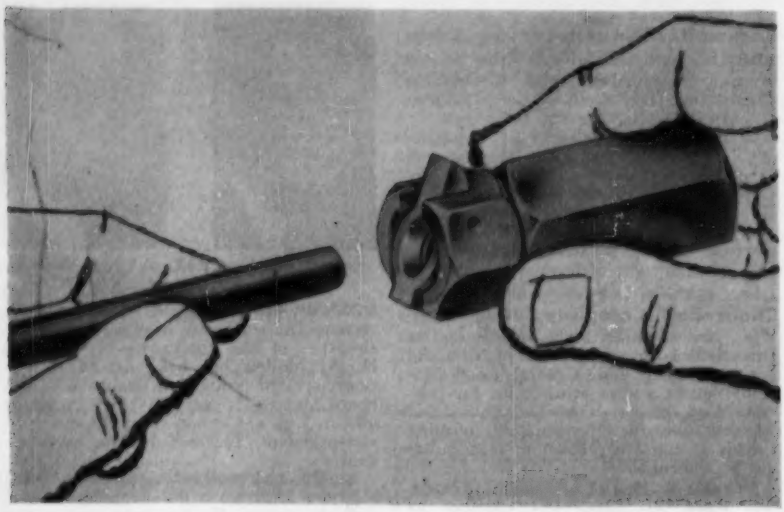
Alloy Steel Products Company has added **Harold C. Templeton** as chief metallurgist. In this post, Templeton will direct metallurgical research in corrosion-resistant alloys and supervise the synthesis and composition of alloys used in Aloyco corrosion-resistant valves. He will also furnish corrosion consulting services to Aloyco customers.

Templeton was formerly chief metallurgist for the Lebanon Steel Foundry. He is a Metallurgical Engineer, receiving his degree from the Colorado School of Mines, and served five years as an officer in the Corps of Engineers during World War II.

United States Steel Corporation has appointed **Bobby F. Kelier** as field representative at Hobbs, N. M., for the Oil Well Supply division. Kelier was employed in June, 1956, at the Hobbs store. Prior to his employment with "Oilwell" he had eight years oil field sales and service experience. He attended Butler University, Indianapolis, Ind.

What's New in Equipment . . .

. . . and Manufacturers Literature



Push On-Pull Off Tube Plug and Connector—A new self-sealing, automatic locking "Push On-Pull Off" Tube Plug and Connector recently introduced, provides a fast, safe and efficient method of attaching pressure and vacuum lines to straight end tubing. The unit is ideally suited for production and maintenance applications involving pressure or vacuum testing, because it permits instantaneous, leak-proof connection of the element under test to the vacuum or pressure source without the use of tools, threading, soldering or brazing. It also has wide application wherever pressure and vacuum lines are used, such as on heat exchangers, refrigeration units, tube assembly, etc. To use as a tube plug, insert ¼" pipe plug to seal end of connector.

To attach the connector, it is merely pushed over the end of the tubing into the "stop" position. This operation automatically locks the tubing into place in a leak-proof seal, ready for vacuum exhausting or pressure filling. The connector is designed to operate at any pressure to 1000 psi and any vacuum to 25 microns.

Disengaging the units is a split-second operation. Pushing the lever permits the connector to be pulled off the tube end. It is equally efficient for air, water, steam, oil, Freon 12, Freon 22, etc., and is suitable for temperatures from —40 F. to +275 F. It is available in 3 standard sizes: for ¼", 5/16" and ⅜" O.D. tubing. Other sizes are in the process of development. Mechanical Products Corp.

Circle E1 on the card.

World's Smallest Calculator—This convenient vest-pocket calculating device is the most convenient form of the circular slide rule that has ever been developed. It is only 3 inches in diameter. The Controller is made of aluminum weighing only one ounce. It can perform all the calculations of a 10-inch slide rule but has the carrying convenience of a pocket watch. Controller—Calculators.

Circle E2 on the card.

Cathodic Protection Equipment—A 32-page booklet on cathodic protection equipment for corrosion control is now available. Illustrated with numerous photographs and drawings, the data include extensive technical information on installation, inspection and maintenance of the described equipment together with various schematic circuit diagrams. Also included is a listing of other technical bulletins. Standard Telephone and Cables, Ltd.

Circle E3 on the card.

Tube Accessory Catalog—Completion of an all new Catalog 81 has been announced by The Gustav Wiedeke Company, since 1892 manufacturers of tube expanders, tube cutters, and operating accessories. This new 32-page catalog contains complete specifications of the entire product line of Ideal Tube Cutters and Expanders, plus all necessary information pertaining to a complete line of operating accessories.

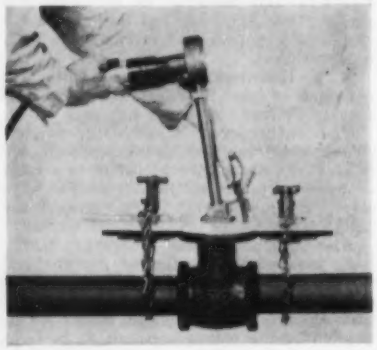
Many demonstrations of products application are included among the 300 illustrations contained in the book. Also enclosed are all necessary tables of sizes, complete ordering information and a list of nationwide and foreign distributor locations. All of this information has been indexed for quick and handy reference.

Catalog 81 will be of interest to manufacturers, erectors, and repairmen of fire tube boilers, water tube boilers, condensers-coolers, heat transfer units, refinery still tubes, and miscellaneous units. Gustav Wiedeke Co.

Circle E4 on the card.

Rare Chemicals—A new brochure listing the expanded line of Special and Rare Chemicals produced at its plant in Jersey City is now available. This brochure also describes the other activities of this company in the distribution of Industrial, Laboratory and Rare Earth Chemicals. City Chemical Corporation.

Circle E5 on the card.

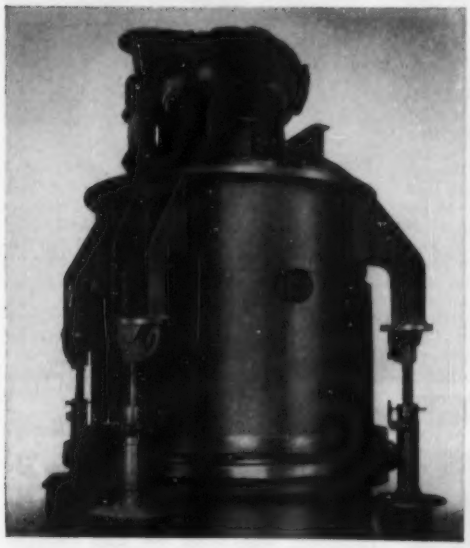


Valve Grinder—Savings as high as 400 percent on labor, increased production, fuel savings and power gains are some of the unusual benefits claimed from the use of this new valve reseating grinder. One man using the new machine can regrind any globe or gate valve from ¼ inch to 12 inches without removing the valve from the line.

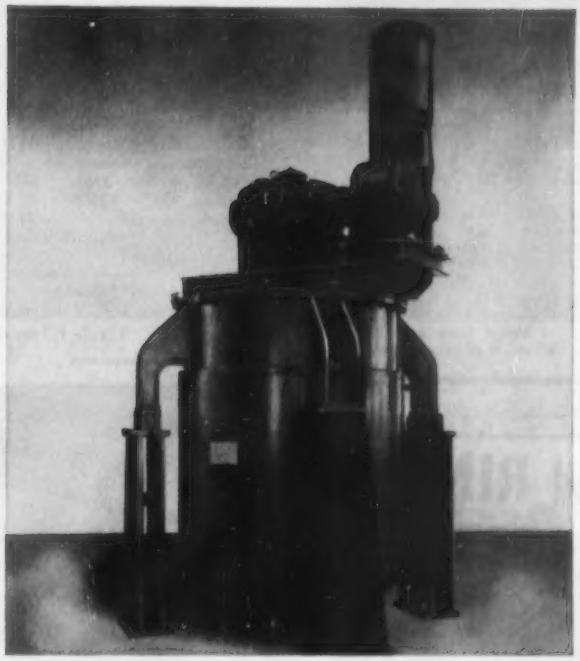
Since one man using the new machine can grind any valve right in the line, the need for three and four man crews to remove and replace defective valves is completely eliminated. Further, the machine reduces or does away entirely with costly replacement valve inventories. The machine guarantees accuracy by refacing irregular valve seats from the same "reference point" that was used by the manufacturer in machining the original seat.

Buflovak...50 years experience matching kettles with requirements

500-gallon one-piece cast jacketed Pressure Saponifier with Double Motion Agitator.



1500-gallon Dowtherm heated, jacketed Kettle with Double Motion Agitator and Thermocouple.



3000-gallon steam jacketed, fabricated steel Grease Mixing Kettle.

To a great extent, processing profits depend upon the quality and efficiency of the processing equipment. Proper equipment design is in turn determined by such factors as end product, quantities to be handled, method of heating and cooling, agitators and drive to be employed, heat source, and high or low temperature control.

Blaw-Knox engineers have the years of practical experience and technical know-how necessary to combine all these factors into equipment that will best meet *your* processing needs. We can build kettles to your design; or, engineer, design and construct kettles to meet your requirements. Either way, Buflovak Kettles are your assurance of highest processing profits. Write or call us today about *your* processing problem.

a broad process equipment service

Kettles of every description constitute but one phase of Blaw-Knox Process Equipment design, engineering and fabrication service for the chemical, food, pharmaceutical, plastic and resin, petroleum, rubber and other industries:

EVAPORATION • DRYING • FLAKING
MIXING • IMPREGNATING • REACTION
VULCANIZING • SOLVENT RECOVERY
SOLVENT EXTRACTION • STERILIZING
CRYSTALLIZATION • DISTILLATION
POLYMERIZATION • GAS CLEANING
GAS ABSORPTION • VAPORIZATION
CONDENSATION • HEAT TRANSFER
LOW AND HIGH PRESSURE PROCESSING

Write for Bulletin 356-R for more information on Buflovak Processing Kettles for heating, cooling, mixing, drying, concentrating, crystallizing and reactions.

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY
Buflovak Equipment Division
1601 Fillmore Avenue, Buffalo 11, New York

Makers of process equipment engineered for any pressure, temperature, capacity or reaction

For more data on advertised products, use Readers' Service Cards, last page.

New Portable Darkroom for Fluorescent Inspection

The Mineralab—most complete and practical cabinet ever designed for fluorescent inspection—in the lab or in the field.

Short and long wave ultra violet as well as white light—all ready for instant action at the push of a button.

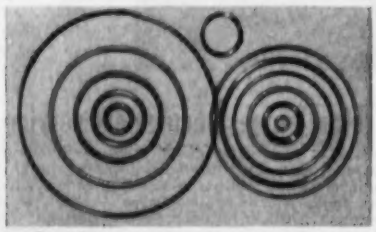
Light-tight doors on both sides and front. Convenient accommodation for microscope with full illumination of stage and sufficient darkness for daylight examinations.

Operates on batteries for field use, on 110-volt AD-DC in lab. Light weight, compact for easy carrying.

As a complete, self-contained darkroom, the new MINERALAB is ideal for "on the spot" inspection close to the problem being studied—for inspection of oil cores and cuttings at the rig or in the open laboratory.

Write for full details to Black Light Corp. of America, Distributors for Ultra-Violet Products, Inc. 5114 Walnut Grove Ave., San Gabriel, Calif. (Offices in principal cities.)

Need RING GASKETS?



Call CHICAGO-WILCOX for PROMPT SERVICE

Since 1906, Chicago-Wilcox has served the refining industry with gaskets for every requirement. These A.P.I. ring gaskets are typical. Used on ring-type flanged joints in high pressure lines. Made of soft iron, standard steel alloys or any of the non-ferrous metals to any desired cross section.

Send specifications for quotations and prompt-delivery schedule.

CHICAGO-WILCOX MFG. CO.
7703 Avalon Avenue, Chicago 19, Ill.
Phone: SAginaw 1-1900

New Equipment . . .

Strict adherence to the original "reference point" makes the reground valve as tight as new. Leavitt Machine Company.

Circle E6 on the card.

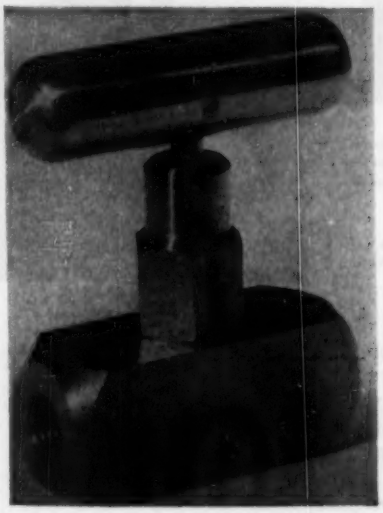
Direct Standard for Acids—The laboratory world's first perfected primary standard for acids, a high-purity stable material permitting direct one-step acid standardization.

Until now, bases could be satisfactorily standardized against potassium acid phthalate, but for acids no comparable acidimetric standard was available. (Laboratory workers generally had to standardize their acids against bases, which first had to be standardized against the phthalate—a double step.)

The new standard—Certified Tris (hydroxymethyl)-aminomethane (or THAM)—is individually lot-analyzed, with a minimum assay of 99.90 percent . . . melting-point range (heated at rate of 6 C. per minute) is 170.9-171.3 S. . . . and the pH (for a 0.05-M solution at 25 C.) is 10.4.

As an acidimetric standard, THAM has 6 advantages that make it ideal for dilute solutions of strong acids: (1) a high equivalent weight of 121.36; (2) low moisture pick-up; (3) doesn't absorb CO_2 from the air; (4) long shelf life (over 2 years if kept tightly closed); (5) reacts stoichiometrically; (6) doesn't require further drying for ordinary laboratory standardizations. Fisher Scientific Company.

Circle E7 on the card.

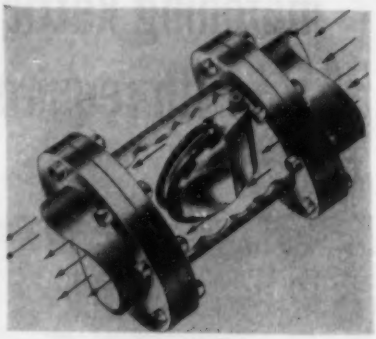


Metering Plug Valve—Made from stainless steel barstock, and incorporating a replaceable plastic seat made from nylon, this valve was specifically designed to give exceptionally long trouble-free bubble tight reseating action. The plastic seat withstands metering action and unless severely damaged will continue to give leak proof shutoff action.

The straight through high volume passages and the nonlubricated rising stem design eliminates flow directed against the stem seat and threads and the resultant erosion which is usually found in valves with conventional over and under passages.

Simplicity of design makes this small valve an item which can be repaired more rapidly and economically than it can be replaced. With the valve installed in the line, and system pressure off, the stem, seat and bonnet can be replaced without breaking the system connections. Anderson, Greenwood & Co.

Circle E8 on the card.



Plastic Check Valve—A new check valve made of polyvinyl chloride for handling corrosive gases, vapors and fluids has just been developed and introduced.

Called Technocheck-PVC, the valve employs a unique and successful principle used by the company in the manufacture of their metal check valves.

This valve can be used in all PVC systems and installed in any position for handling salt solutions, fuels and oils, acids and alkalies, food products, liquors, alcohols and other materials for which PVC is recommended.

Temperature and pressure limitations are the same as those for PVC.

Bodies are fabricated of tubing and flanges meeting ASA Standards. Internals are of PVC, with sealing members of plasticized PVC, Neoprene, or Buna N, all reinforced with nylon for high strength. Hardware is of stainless steel.

Available in standard sizes from 1" to 8"; male threaded ends in sizes from 1" to 4"; or with standard flanges or socket ends. Techno Corporation.

Circle E9 on the card.

Leak-Proof Centrifugal Blower—Development of a leak-proof centrifugal blower for handling corrosive or toxic gases at high temperatures and system pressure has just been announced.

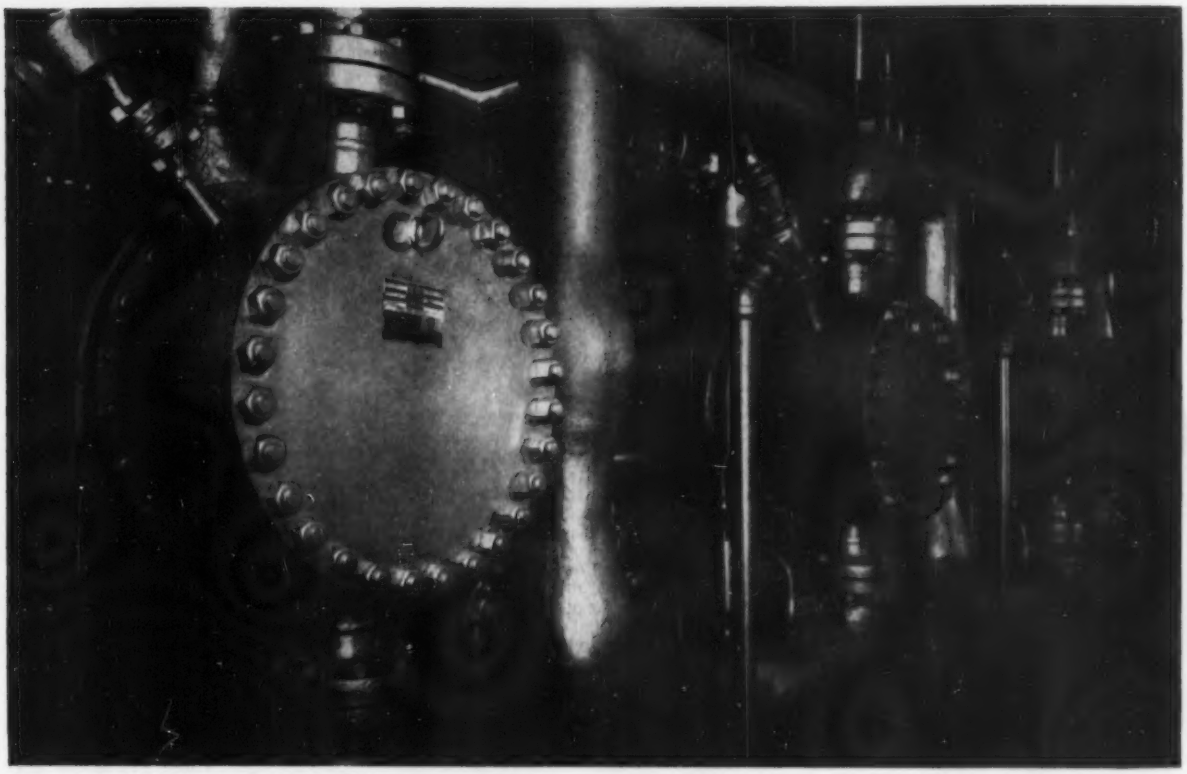
The blower will handle 20 cfm of gas having a specific gravity of 6 and will develop a 150-foot head in a 2000-psi system. It is designed to operate at gas temperatures up to 500 F.

The unit consists of a centrifugal blower and canned motor sealed in a heavy stainless steel enclosure. The motor rotor and bearing components are located in the lower portion of the unit which is filled with water. Fluid piston radial and thrust bearings make the leakproof design possible.

An auxiliary pump impeller mounted on the main impeller shaft of the blower pressurizes the bearings. Contact between shaft and bearing occurs only during start-up or shut-down of the blower.

Corrosiveness of the water in the rotor and bearing cavity is limited by labyrinth seals at the water-gas interface. Water level is maintained by adding pure water at the bottom of the unit and tapping it below the interface seal.

Water is circulated through built-in cooling coils which remove the heat from



THE ROSS STORY

Special Heat Exchange Equipment for Power Plants

Simply stated, Ross designs and manufactures heat exchangers for virtually all conditions and applications, particularly units of a highly specialized nature, such as high pressure power plant equipment...bleeder heaters and fuel oil heaters, for example.

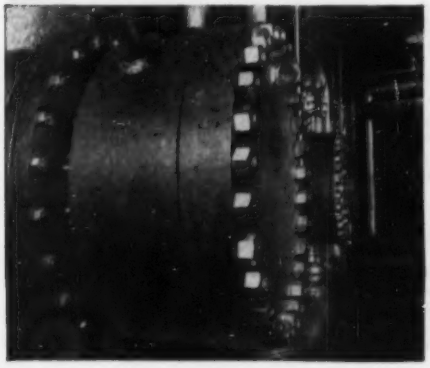
The installation of 6 Ross High Pressure Fuel Oil Heaters (illustrated) at the Pacific Gas and Electric Co.'s Station P Steam Plant in San Francisco is typical. Featuring forged oil channels with integral tube sheets and a double tube sheet arrangement to insure against any possibility of fuel oil contaminating the steam system, these rugged units demonstrate Ross' resourcefulness and experience in dealing with both the average and the specialized power engineering problem.

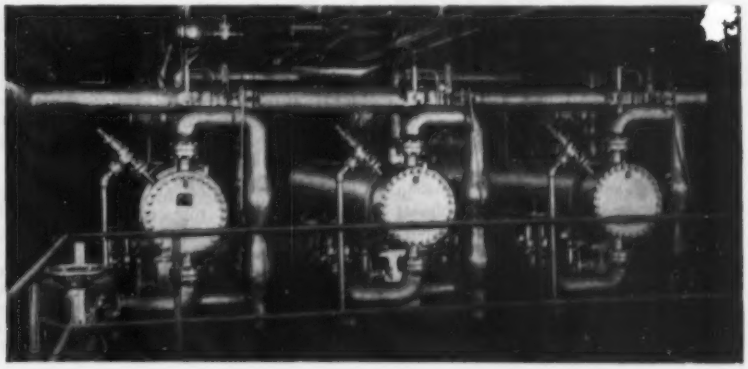
Your requirements, too, can be met with the same, exacting Ross attention to details. Inquire now. Ross offices are in all principal cities.

For recommendations on specialized heat exchangers, as well as on surface condensers, turbine oil coolers, engine oil and water coolers, compressor inter and after coolers and related power plant equipment, you'll profit by consulting a Ross engineer.

ROSS

ROSS HEAT EXCHANGER DIVISION
of
AMERICAN - Standard
BUFFALO 13, N. Y.
In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

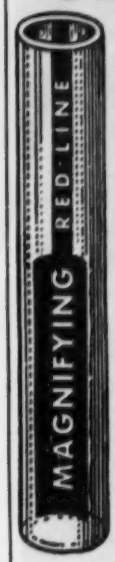




For more data on advertised products, use Readers' Service Cards, last page.

ERNST
HIGH PRESSURE
GLASSES
and GASKETS

All sizes to fit your gages and valves



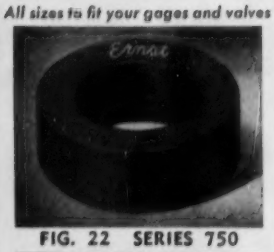


FIG. 22 SERIES 750

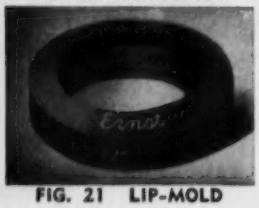


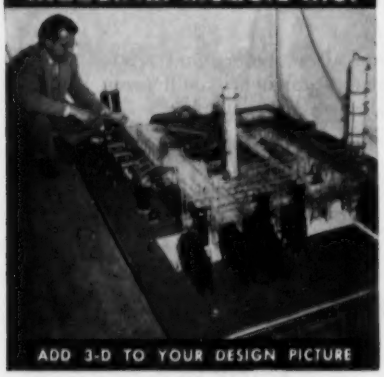
FIG. 21 LIP-MOLD

STATE YOUR REQUIREMENTS

All shipments from stock.
Send for Catalog

ERNST WATER COLUMN & GAGE CO.
Livingston 6-1400 LIVINGSTON, N. J.

Industrial Models Inc.



Industrial models help you see through construction and design problems before the blueprint stage. Save up to 30 times model cost by more efficient

- Plant or Laboratory Layout
- Construction Planning
- Piping Design
- Personnel Training
- Expansion Planning
- Subcontract Bidding

Save time and effort, cut costs by putting Industrial Models' experienced engineers and craftsmen in your design picture.
Write for detailed brochure.

Industrial Models, Inc.

New Equipment . . .

the motor and maintain temperatures of less than 210 F. in the rotor and bearing cavity.

To facilitate inspection, the blower is arranged so that all rotating and bearing parts can be removed after taking out a threaded cover plug and its seal weld. To inspect the stator and cooling coils, a seal weld and the main flange bolts are removed.

The blower has application in any industry where toxic and dangerous gases must be moved without leakage. Allis-Chalmers Manufacturing Company.

Circle E10 on the card.

Fin-Tube-Heat Exchangers—A new two-color, eight-page bulletin on fin-tube-heat exchangers has been announced. The bulletin describes the excellent heat-transfer characteristics of longitudinal fin tubes, which feature U-shaped fin channels integrally bonded to the tubes by heliarc welding. Included is a table of dimensions, a type designation table and finside coefficient and finside pressure-drop charts for all sizes of exchangers. Alco Products, Inc.

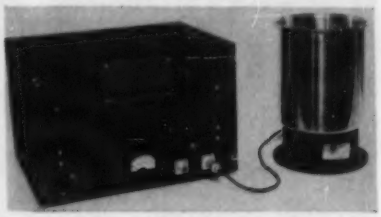
Circle E11 on the card.

New Hacksaw—This new tool combines many of the features of hack, coping and keyhole saws. Depth of cut is unlimited since the enitre frame remains on the operator's side of the material. Inside cuts and cuts in confined areas are also possible because of its unique design.

The secret of its operation lies in the sliding blade support with its molded finger rest. Once the saw cut is blade deep or, when starting with a drilled hole on inside cuts, the nose of the spring loaded blade support rests against the material being sawed and only the blade moves back and forth through the cut. Ample support for the blade is provided as the finger rest stays directly above the portion of the blade doing the cutting. When starting an edge cut, the support may be locked in the forward position. The saw is then used in the convenitonal manner.

Imported from England, the saw is made of diecast aluminum and fine English steel. Three hardened steel balls provide bearing surface against the top and both sides of the blade. The Leytool saw will take either 10-inch or 12-inch standard hacksaw blades. A pistol grip handle gives the operator complete control. Runout is eliminated since the blade is held rigid by both handle and blade support. Hallbee Products Company

Circle E12 on the card.



Ultrasonic Cleaner—Announcing a low frequency ultrasonic cleaner for small parts cleaning, blind hole washing, removal of radioactive contamination, printed circuit cleaning and other difficult cleaning operations. The standard unit consists of an electronic generator delivering up to 100 watts of energy to crystal transducers mounted on a one gallon stainless steel tank. Two cleaning tanks may be used alternately without disconnecting either one so that one tank may be used for removing large amounts of soil and the other may be used for final cleaning or two different solutions may be used. The only controls are an off-on switch, a frequency adjusting knob and a toggle switch to operate either transducer. Alcar Instruments, Inc.

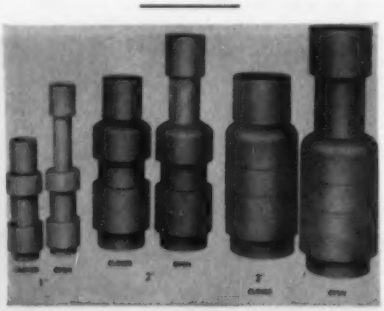
Circle E13 on the card.

Heavy Duty Grinders—Three new heavy-duty die grinders, in level throttle or Q.A.W. versions, have been announced. Seventy-five percent of the parts in the new die grinders are interchangeable in models that range from 3-inch grinders at 12,000 rpm to ¼-inch collet-type tools at 20,000 rpm.

Noise level is kept low by channelling exhaust air through more than 100 milled, gear-like slots around the circumference of the motor housing. The turbulence thus set up effectively reduces the characteristic exhaust air noise. Escaping air is diverted from the work, and away from the operator's hands through a thin-walled steel deflector shell which can be rotated through 360 degrees.

Cylinder liners are ribbed for strength and muffling qualities, and end plates are machined from steel, carburized, and hardened to a glass-like finish, greatly extending end plate life. Master Pneumatic Tool Company, Inc.

Circle E14 on the card.



Slip Type Pipe Expansion Joint—The first slip type pipe expansion joint of unplasticized polyvinyl chloride has just

SERVING THE
PETROLEUM
NATURAL GAS
CHEMICAL
AND ALLIED
INDUSTRIES

WYATT C. HEDRICK ENGINEERING CORPORATION

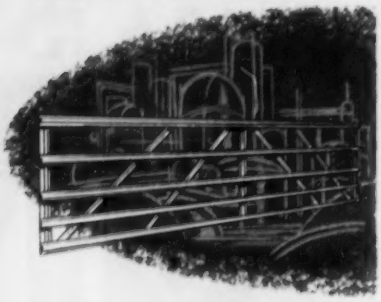
HOUSTON, TEXAS

CONSULTATION, PROCESS AND DEVELOPMENT ENGINEERING, SURVEYS AND ECONOMIC STUDIES ARE A PART OF OUR BROAD ENGINEERING SCOPE.

DETERMINATION OF THE REQUIREMENTS FOR RAW MATERIALS, UTILITIES AND PLANT INVESTMENT PLUS AN EXTENDED FORECAST OF EARNINGS WHICH PROPERLY RELATES THESE ITEMS IS NECESSARY FOR A REALISTIC RE-EVALUATION OF YOUR INTEREST IN ANY PROCESS.

For more data on advertised products, use Readers' Service Cards, last page.

LIFE-TIME GATES
SOLVE YOUR GATE PROBLEMS FOREVER



Life-Time Gates have the strength, durability, efficiency, safety and economy that solve your gate problems permanently. The patented design features a rigid frame of rolled-edge corrosion resistant aluminum or galvanized steel. Specially designed hinges and latches are practical, compact and rugged. Order the original and genuine Life-Time Gate from . . .

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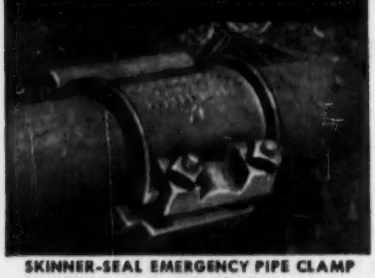
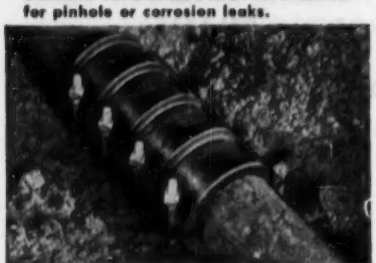
TO REPAIR PIPE LEAKS—
QUICKLY, PERMANENTLY
ANY PRESSURE — ANY TEMPERATURE



SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.



SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

New Equipment . . .

been introduced. It is made in 1", 2" and 3" sizes, and may be used with piping of smaller diameters by employing reducing bushings. All sizes allow an expansion of 3¾".

The new expansion joint is designed for use with rigidly fixed PVC piping subjected to thermal cycles. It has a Neoprene "O" ring packing and is suitable for a wide range of corrosive services. When made of normal impact PVC, the 1" size has a pressure rating of 205 psi at 75 F., and of 120 psi at 140 F.; the 2" size has a pressure rating of 170 psi at 75 F., and of 100 psi at 140 F.; the 3" size has a pressure rating of 150 psi at 75 F., and of 90 psi at 140 F.

The joint has been tested at pressures up to 325 psi, and temperatures up to 140 F. Tube Turn Plastics, Inc.

Circle E15 on the card.

Non-Freezing Copper Deactivator—A new non-freezing copper deactivator formulation which will remain liquid at temperatures of zero degrees Fahrenheit and above is being offered now to the petroleum refining industry.

Traces (usually less than one part per million) of copper are often found in gasolines. These copper impurities exert a strong catalytic effect on the oxidation, gum formation and tetraethyl lead decomposition in commercial gasolines. Copper deactivators react with these traces of copper and destroy their catalytic activity.

Called UOP Copper Deactivator-AW (50), the new formulation contains Universal's regular active ingredient in 50 percent concentration in solution. It is designed to eliminate the problems of freezing and low temperature pumping which are characteristic of regular grade deactivators.

Other characteristics of the new formulation are improved color and better solubility, particularly at lowest winter ambient temperatures. It has been found that the improved solubility and pumping properties make AW (50) especially adaptable for direct injection into gasoline or other refinery streams without dilution with aromatic solvents, a common practice when other metal deactivators are used. Universal Oil Products Company.

Circle E16 on the card.

Demisters—For the separation of liquid and vapor phase materials, is graphically illustrated and described in a new bulletin.

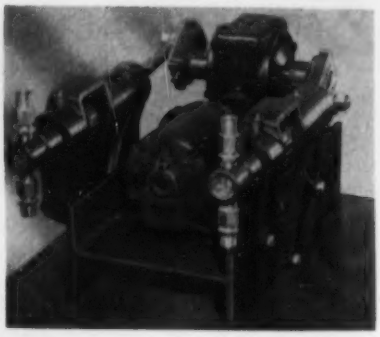
Chemical and petroleum applications, to increase throughput capacity, improve process efficiency and overhead quality while reducing contamination and liquid loss, together with engineering and installation data, are clearly presented for easy reading and reference.

This bulletin also provides information on solvent extraction with liquid-liquid extractors and line separators. Otto H. York Company, Inc.

Circle E17 on the card.

Steel Pipe Specification Guide—Engineers, buyers and others involved with the problem of determining the proper specifications to apply to various carbon, alloy and stainless steel tubing, pipe, seamless welding fittings and flanges, will be interested in this four-page folder. It is a ready cross reference between the steel, the application and the specification covering the product. Reference specifications are those of the ASTM, AAR and a number of special B&W specifications covering the products mentioned. Babcock & Wilcox Company.

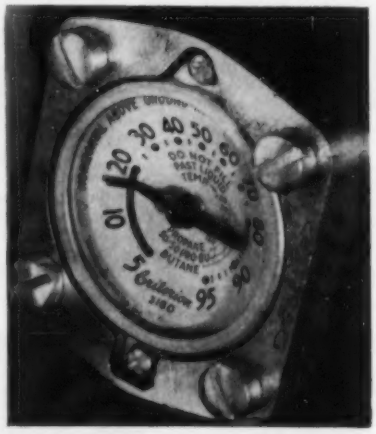
Circle E18 on the card.



New Proportioning Pump—Exceptional feeding accuracy, positive feed rate setting, and economy of initial and upkeep costs are features of the new Model 1140 Proportioneer (chemical proportioning pump).

The plug-in reagent end and other standardized mechanical components are readily accessible for easy servicing. This pump also features the new, unique Vane-Guide check valves (with reversible seats) and minimum clearance volume cylinders of self-purging design. All standard models are equipped with micrometer stroke-length adjustment, with in-motion rate adjustment available if desired. This compact, easily installed unit will handle feed rates from 0.8 GPH to 900 GPH and discharge pressures to 1340 psig. Proportioneers, Inc.

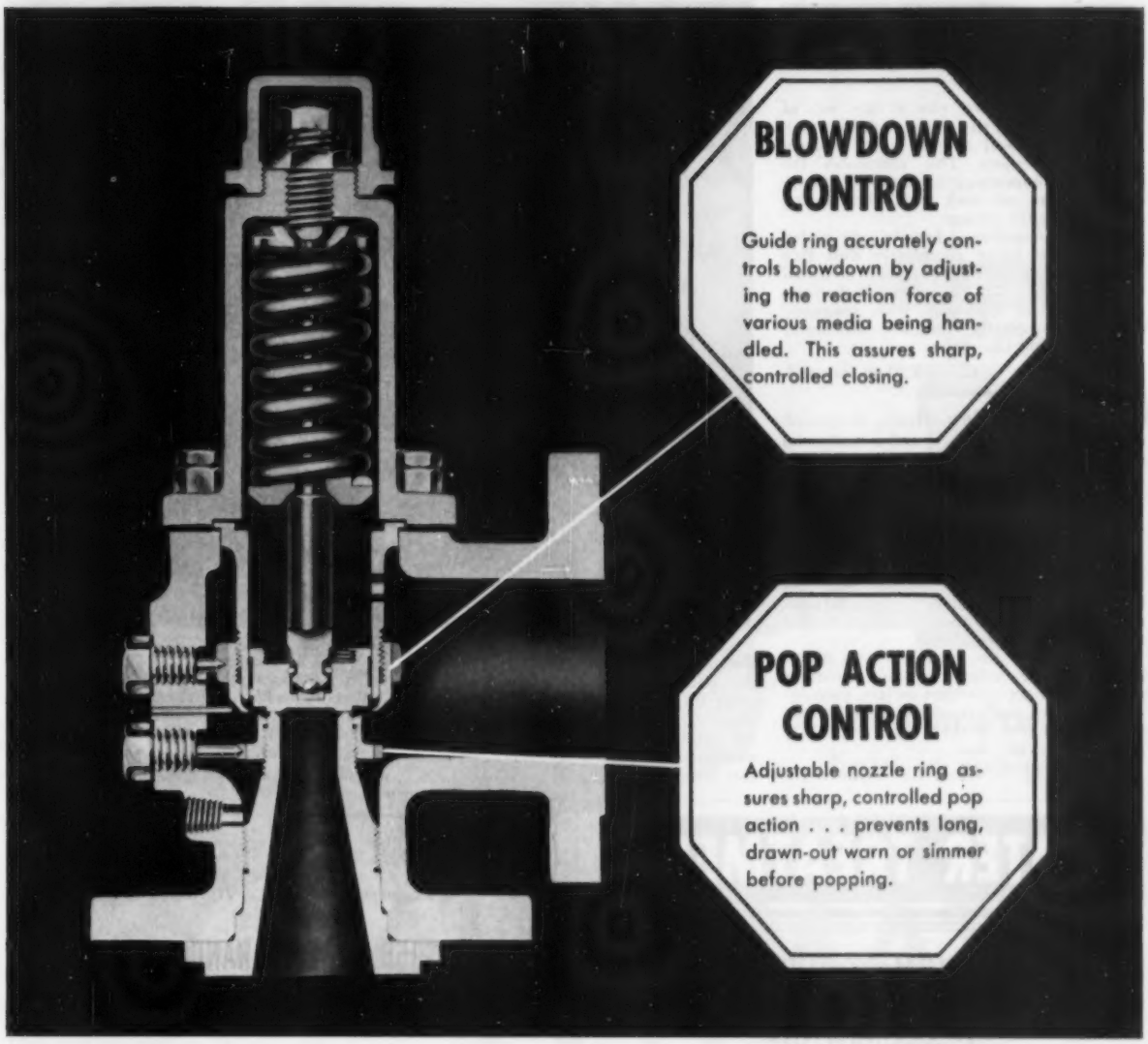
Circle E19 on the card.



LP Gas Gauge—A new LP gas gauge, featuring a heavy duty dial chamber, is ready for marketing.

Housed in a massive cast aluminum body, the dial chamber was redesigned to eliminate breakage problems resulting from transportation or installation of tank systems.

This gauge has a recessed dial chamber and a new angle-view dial face, available in both junior and senior sized LP gas gauges. The dial face, arranged for quicker, easier, more accurate readings, is


BLOWDOWN CONTROL
Guide ring accurately controls blowdown by adjusting the reaction force of various media being handled. This assures sharp, controlled closing.
POP ACTION CONTROL
Adjustable nozzle ring assures sharp, controlled pop action . . . prevents long, drawn-out warn or simmer before popping.

Look for these Signs of Safety

The performance built into every Crosby Nozzle Type Safety-Relief Valve results from basically sound engineering plus materials and workmanship of the highest quality. Crosby Valves meet the need for maximum operating dependability and minimum downtime and maintenance. Because they incorporate generous safety factors, these valves stay on the job for years. Write for Bulletin describing the complete line of Crosby Relief Valves—or ask for our quote on your valve requirements.

CROSBY STEAM GAGE & VALVE COMPANY
43 KENDRICK STREET, WRENTHAM, MASS.

Crosby
KEEPS PRESSURE ON THE SAFE SIDE

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

removable.

Two small screws, one at the top of the dial chamber, the other at the bottom, makes its removal simple when replacement is necessary. This eliminates the costly, time consuming operation of pumping fuel from one tank to another during a possible gauge change.

The dial chamber is hermetically sealed to insure its being completely dust free and water tight. The chamber is sealed off from the gauge's main mechanism, which is float operated with magnetic drive, as originally designed. Rochester Manufacturing Company.

Circle E20 on the card.

Computer Catalog—Newly developed systems for data handling and a new series of analog computers are described in Catalog C-703.

Engineered systems described include those for data reduction, data handling, data logging, industrial measuring and recording and industrial process control.

Three new analog computers, plus four components for control systems, are outlined in the new catalog. Components include amplifiers, electronic multipliers, and function generators.

The catalog also describes news developed frequency meters, decimal counting units, events-per-unit-time meters, time interval meters, nuclear scalers, and nuclear sample changers. Berkely Division, Beckman Instruments, Inc.

Circle E21 on the card.

Resuscitator—In critical emergencies, the portable-model resuscitator can often avert tragedy. It has proved a lifesaver for those stricken by heart attacks or overcome by suffocation, as in drowing, carbon monoxide poison, electric shock, strangulation and asthma.

The all-purpose "Handy" resuscitator is dependable, simple to operate, and so light that it can be easily carried by one person. As a resuscitator, it automatically inhales and exhales for the patient being treated and automatically adjusts to his lung capacity. As an aspirator, it furnishes suffi-

WATER TREATMENT

PURIFICATION • CONDITIONING RECLAMATION

Call the nearest DROKE representative.

He has the COMPLETE LINE of equipment and processes for handling your water treatment problems.

Make your plant more efficient and profitable.

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Small in size...
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AUTOMATIC SAMPLER

Here's a new compact, completely automatic, magnetically powered and electronically controlled sampler designed to provide a continuous sample from process or pipe lines.

USERS GET ALL THESE IMPORTANT ADVANTAGES.

- ★ Proportional to time or flow
- ★ Settings for 20 to 300 cycles per minute for more accurate sampling
- ★ No packing glands, no leakage
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- ★ Simple to install and service
- ★ LOW initial cost . . . LOW maintenance cost
- ★ Completely explosion-proof . . . no pressure relief valves required
- ★ No hold-up time from pipe line to sample receiver; because a portion of the stream is by-passed through the sampler

Before you buy any other sampling unit, write for full details on this New Automatic Sampler.

GILBERT & BARKER MFG. CO. • WEST SPRINGFIELD, MASS. • TORONTO, CANADA

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

cient suction to clear water, mucus or vomitus from the throat. As an inhalator, it supplies oxygen to be absorbed by spontaneous respiration.

The compactly built breathing mechanism—small enough to fit in the palm of the hand—can be used 200 feet away from the oxygen supply. This makes it possible to reach and revive accident victims in tunnels, tanks and other hard-to-get-to places. National Cylinder Gas Co.

Circle E22 on the card.

Pressure Transmitter—A redesigned, low cost, pneumatic pressure transmitter, operating on the force-balance principle is available for services involving viscuous substances, or materials which solidify in the static lines of bourdon tubes. It also has wide application for liquid level indication on open tanks containing viscous materials or those with solids in suspension.

The Model "P" is unique in that it utilizes simple, flat diaphragms in lieu of bellows. This eliminates the problem of viscous materials hardening in bellows convolutions. Diaphragm material is of rubber, Teflon, or stainless steel, depending on the temperature range and corrosiveness of the service. The pilot is completely isolated from the pressure diaphragm so that controlled gas or liquid cannot back up into air lines in event of diaphragm failure.

Bulletin P-2520-2, describing the new pressure transmitter in detail, is available from Conoflow Corporation.

Circle E23 on the card.

Instrument Catalog—Over one hundred measuring, transmitting, receiving, recording, and indicating instruments and control components for power and process applications are described in a new 8-page bulletin. Includes detailed literature reference for each product as well as twenty-four instrument and control applications. Addresses and phone numbers of all district offices also listed. Request Bulletin G15-1, Bailey Meter Company.

Circle E24 on the card.

Slip-on End Caps of Neoprene—Here's an economical way to guard pipe and tubing against costly internal corrosion during storage. A Texas manufacturer is now offering slip-over and roll-on end caps made of neoprene that effectively seal out air, moisture, corrosive fumes, dust—and small animals.

By simply adding a small amount of dehydrating agent before slipping on the easily fitted caps, the inside of expensive alloy tube stock is protected from corrosion. Ideal, too, for threaded pipe, the new caps retard drying of thread dope and keep the threads free of sand and grit.

Two types are currently available: a lightweight roll-on cap for pipe 2 to 10 inches in diameter; and a heavier, slip-on cap for 2- to 20-inch diameter piping. The standard slip-on covers have a wall thickness of about ⅛ inch.

Because they are made of rugged neoprene, the new end caps will stand up to rough handling and repeated re-use. Unlike ordinary rubber, neoprene also is highly resistant to oil, acids and other chemicals, sunlight, and weather.

While the new caps were designed primarily for stored piping, they are equally effective for protecting heat exchanger tube bundles, well casing, and various other tubular goods for oil field and refinery applications. The tough neoprene covers can be used to afford complete protection all the way from supplier to installation. Protokap Inc.

Circle E25 on the card.

Explosion-Proof Motors—Latest design features of explosion-proof motors in NEMA rerated ratings of ½ to 30 hp (Type GZZ) and in non-rerated ratings of ½ to 100 hp (Type APZZ) are described in this latest bulletin.

New features of the rerated motors include a diagonally split cast iron conduit box for increased accessibility and ease of wiring, and a rotating shaft seal on the shaft extension end of a material impervious to corrosive agents.

CUSTOM FABRICATING DATA—*Request New Brochure K-56*

This information on plant facilities and services will be of value to purchasing, procurement and engineering personnel when planning the custom fabrication of...

STEEL PLATE

for the Petroleum Processing Industry on the West Coast

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Craftsmen in steel plate and alloys up to 1"

VIKING ROTARY PUMPS

- **Cut-Away View Showing Viking's Gear-Within-A-Gear Principle**

The unique and unusually simple construction of Viking Pumps . . . with only two moving parts . . . assures you of long, easy-maintenance operation with all grit-free liquids.

Let Southern Engine & Pump Company show you how Viking Pumps can solve your pumping problems. We invite your inquiries.

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How Metallizing saves money in refineries

cuts machine repair costs 80%—
cuts equipment "down-time"—
permits reduced spare parts stocks

Practically any worn machine part—repaired for only 15 or 20% of replacement cost—in minutes and hours, instead of days or weeks.

Pump shafts • Impeller journals • Motor shafts
Rotor blades • Packing areas • Pump plungers

The list of metallizing users in the Petroleum field reads like a Blue Book of the industry. Here are just a few:

Cities Service Refining Co. — Ohio Oil Co.
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Gulf Oil Co. — Socony-Vacuum Oil Co.
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METALLIZING EQUIPMENT COMPANY, LTD.—Cobham near Woking, England

New! **PATTON** *oil seal puller*

SAVE TIME—MONEY
PULLS OIL SEALS, BEARING RACES BRONZE BUSHINGS

The new PATTON Puller does the job quickly and easily without damage to parts and castings. In addition, oil seals, bearing races and dead-end bronze bushings are removed in a fraction of the time formerly required.

Originally designed for the Armed Forces, the PATTON Puller is now used in machine shops and maintenance and repair shops wherever machinery is repaired. PATTON Pullers save costly man hours and prevent unnecessary damage to component parts. Special sizes can be custom-made for specific requirements. Write for details.

Certain areas are available for qualified distributors.

PATTON NO.	AIR FOR. STOCK NO.	HEAD SIZE
PM-8001 (Set)	7900-573278	Comp. Set 7/16" to 1 3/16"
PM-8051 (Set)	7900-573279	Comp. Set 1 11/32" to 4 5/16"
PM-8001-1 assy.	7900-573265-5	7/16" to 17/32"
PM-8001-2 assy.	7900-573265-75	1/2" to 29/32"
PM-8001-3 assy.	7900-573266	1 5/16" to 29/32"
PM-8001-4 assy.	7900-573266-25	31/32" to 1 1/16"
PM-8001-5 assy.	7900-573266-5	1 5/32" to 1 1/4"
PM-8001-6 assy.	7900-573266-75	1 11/32" to 1 3/16"
PM-8051-3 assy.	7900-573267-5	1 25/32" to 2"

Sizes from 3/8" to 4 1/8" available. Pat. No. 2380068 and Pat. Pend.

PATTON
MANUFACTURING COMPANY, INC.
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As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL

The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life*, with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

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Please send me catalog data and full information on Magnetrol Liquid Level Controls.
Name_____
Company_____
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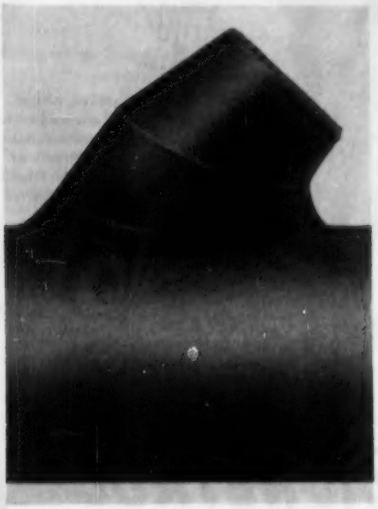
Zone____ State____

New Equipment . . .

The conduit box is bolted directly to the frame, which results in a more compact arrangement.

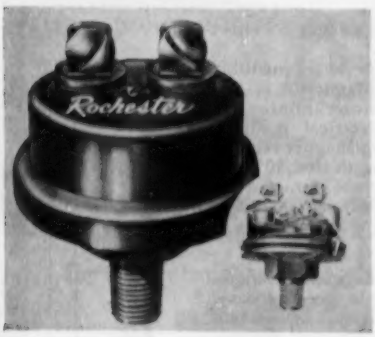
In addition to cutaway views of the motor, the bulletin includes tables of ratings and dimensions as well as a horsepower frame chart. Allis-Chalmers Company.

Circle E26 on the card.



Welding Elbow—A unique branch welding pipe fitting for constructing angular branch connections with a full penetration weld. "Elbolets" are used for making 45 degree connections for directional flow and instrument connections, and for connections into elbows for instruments, drips, and hangar and support connections. Bonney Forge Company.

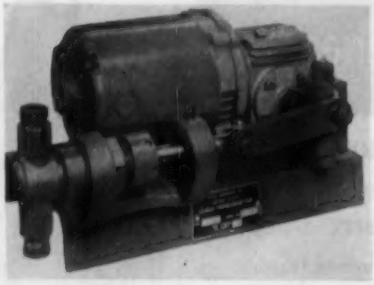
Circle E27 on the card.



Vacuum Switch—A new heavy duty type vacuum switch housed in a hermetically sealed dust-proof steel case features a spring loaded diaphragm, Buna-N-impregnated, protected against heavy vibration, pulsation and shock.

Operation, which is factory calibrated, opens and closes a contact at fixed vacuum values. Available for normal open or normal closed use at zero vacuum with settings up to 22 inches and for use with 6-, 12-, or 24-volt DC or low voltage AC the switch is supplied in either single terminal grounded or double terminal models. Rochester Manufacturing Company.

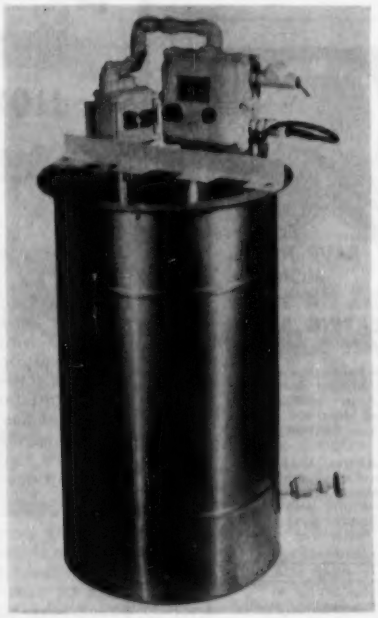
Circle E28 on the card.



Chemical Feed Pump—A new chemical feed pump has just been announced. A compact and simplified pump, it has a maximum capacity of 7 gph/feed and discharge pressures up to 600 psi.

The pump was specifically designed for applications requiring a delivery rate of 7 gph/feed or less. Of the positive displacement, plunger type pump, the model contains many built in operational features such as "capsulated" construction, that are typical of the larger capacity chemical feed pumps. This pump is ideally suited for applications requiring precision and economy in the continuous feeding of chemicals used in water conditioning, chemical process additive feeding, petroleum inhibitor addition and other similar applications. Hills-McCanna Company.

Circle E29 on the card.



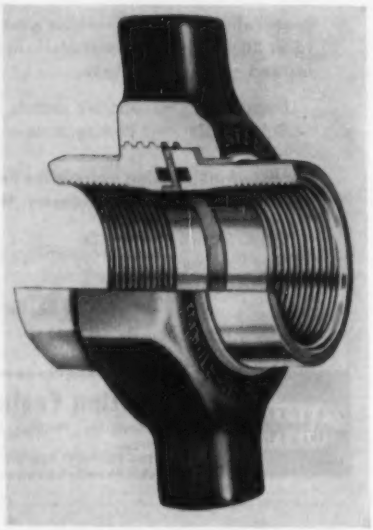
Reid Vapor Pressure Bath—For use in all types of petroleum laboratories where vapor pressures of gasoline are run daily, a new line of explosion-proof Reid vapor pressure baths has been announced.

The unit consists of a stainless steel bath approximately 19 inches dia. x 30 inches high, and is equipped with a single rack for holding 3 bombs or a double rack for holding 5 bombs.

Temperature is maintained at 100 F, within ASTM limits, utilizing a combination of a fully-enclosed armored preset sealed mercury regulator, with electronic relay and motor-driven stirrer. The motor-driven stirrer utilizes an explosion-proof motor, and the electronic relay, pilot light, switch and line switch are mounted in an explosion-proof housing. All explosion-proof fittings, etc., conform to meet the requirements of Class 1, Group C and Group D.

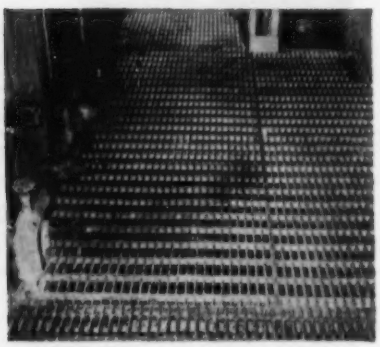
In gasoline testing laboratories, explosion-proof features are of utmost importance in reducing or eliminating fire and explosion hazards. Labline, Inc.

Circle E30 on the card.



Insulating Union—Recommended for use on oil and gas production lines, this insulating is designed to keep current from traveling into adjoining pipe sections. The insulating gaskets rubber impregnated nylon. Two oil-resistant "O" rings form the seat between the male and female ends. The unions are made of forged steel with cadmium plated ends and a parkerized nut. Clayton Mark & Company.

Circle E31 on the card.



Stainless Steel Grating—Metal gratings have long been used in the steel processing industry as self-cleaning floors, stair treads, catwalks, platforms and fire escapes. But now where severe corrosion is encountered the gratings are being made of stainless steel. Armco Steel Corporation.

Circle E32 on the card.

NOISE and PULSATION Can Be Stopped Scientifically!

NOISES from intake and discharge piping of air, steam and gas systems

and

PULSATION and VIBRATION caused by surge in compressor, blower and pressure reduction systems

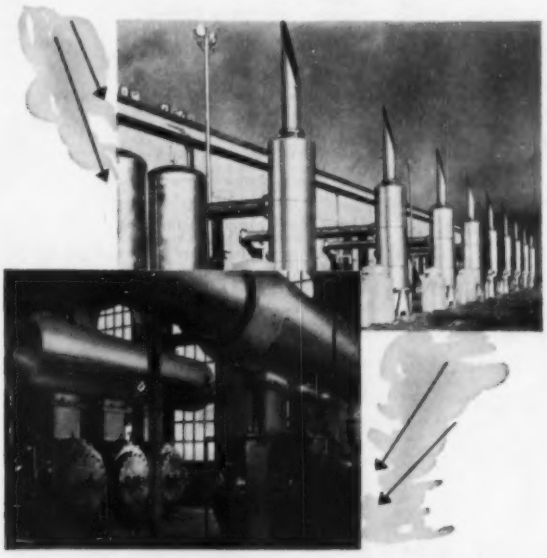
are effectively eliminated by BURGESS-MANNING SNUBBERS

First, the B/M Snubbing Principle is scientifically correct and thoroughly proved in every branch of industry, and

Secondly, every Burgess-Manning Snubber is engineered to the specific application.

Burgess-Manning Snubbers attack noise and pulsation at the source. The pulse and slug of engine or compressor discharge is dissipated before it can be transmitted to atmosphere or other parts of the system. Elimination of the noise and pulsation problem will be money in your pocket through better equipment efficiency, improved production, reduced maintenance, elimination of operating hazards that result in costly errors, and improved neighbor and labor relations.

We invite you to present your problems for recommendations.



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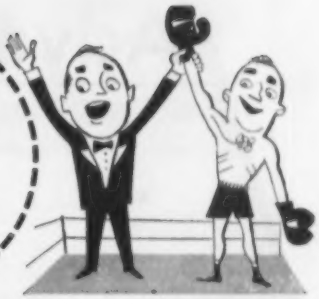
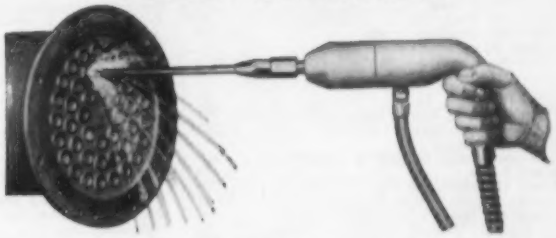
BURGESS-MANNING COMPANY

Sound Engineering 711 East Park Avenue, Libertyville, Illinois
Dallas, Texas

Lightweight Champ by 10 to 1



WILSON PGX
TUBE CLEANER



The Wilson PGX Tube Cleaner weighs only 6½ pounds, but it knocks out scale ten times faster than ordinary mechanical cleaners. It cleans at rates as high as ten feet per minute—removes deposits from flinty hardness to soft gum as well as chemical compounds such as carbonates, sulphates, sulphites, silicates, chlorides, coke, marine growths and iron oxides.

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For more data on advertised products, use Readers' Service Cards, last page.

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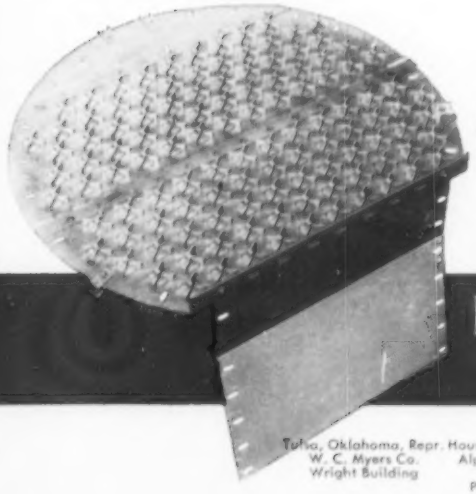

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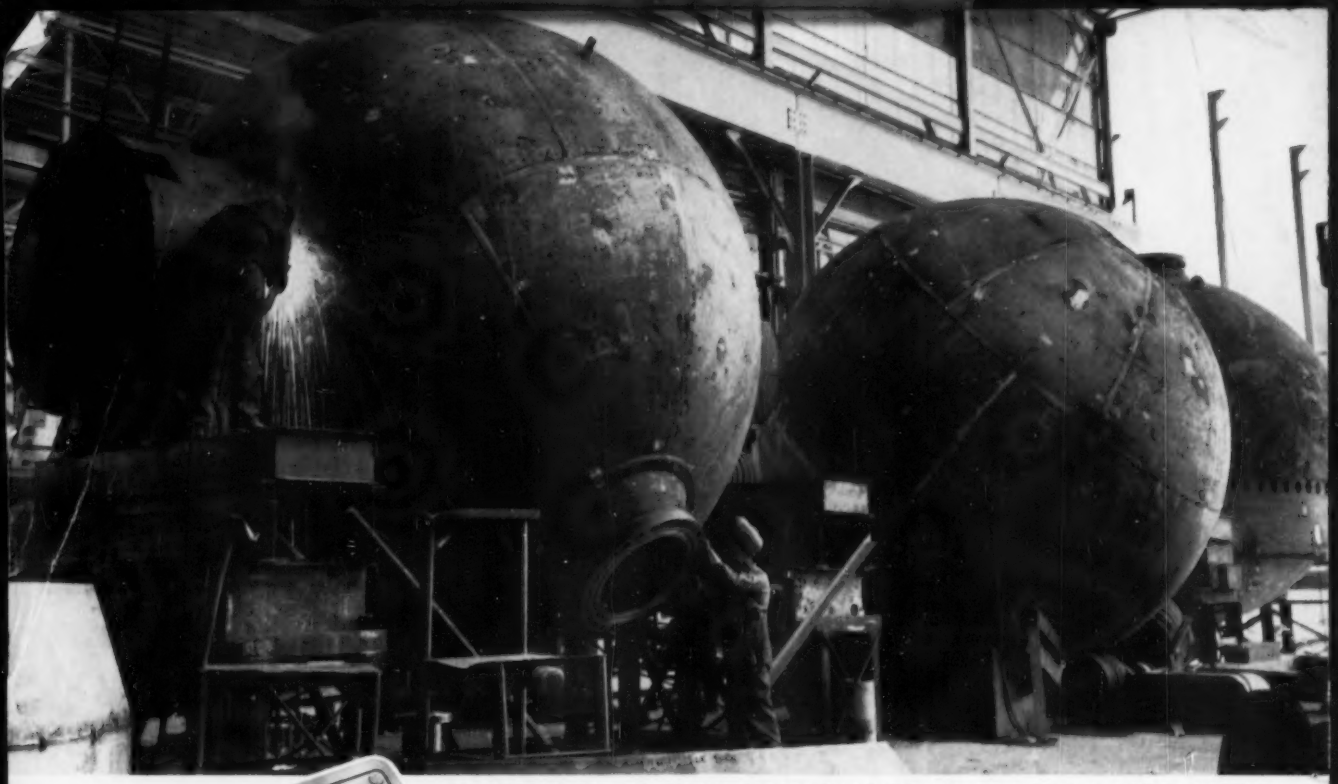

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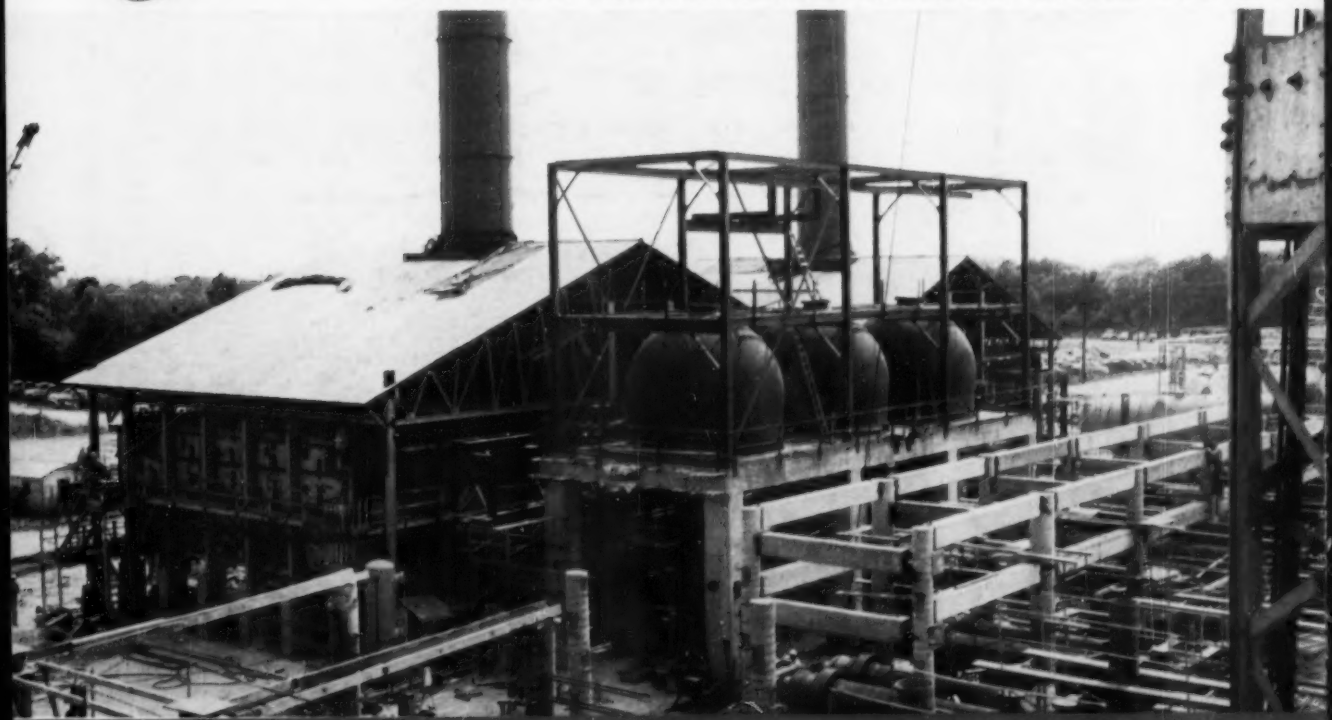

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